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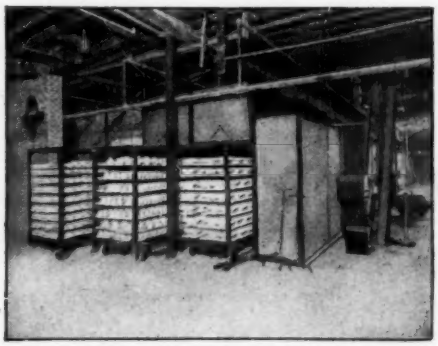

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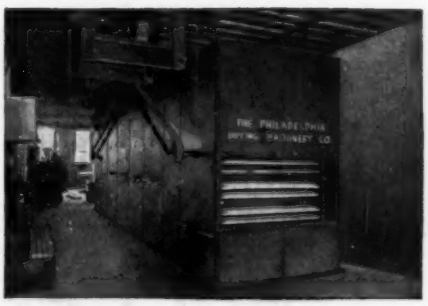

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ORIGINAL PAPERS

WET PROCESS ENAMELS FOR CAST IRON[1]

R. R. DANIELSON AND H. P. REINECKER[2]

ABSTRACT

Wet process enameling of cast iron is becoming of importance because of its application to the enameling of stove parts, sanitary fittings and hardware. This paper is a report of an extended investigation of wet process enamels for cast iron, in connection with the use of a ground coat.

Compositions used in dry process enameling have served as a basis for the work, which includes a study of ground coats and white cover enamels. The effect of varying methods of preparing the frits, mill additions, and the relation of composition of the enamels to such properties as adherence, texture and opacity have been carefully studied.

Ground Coats.—Sintering of most ground coat frits has been found desirable in order to develop best adherence on the castings. Clay gave best results as a mill addition for the ground coats, and flint and feldspar were found to be less satisfactory. Excessive additions of clay or flint produced flaking of the ground coat while feldspar tended to develop blistering. About 15 per cent of clay or 10 per cent each of clay and flint are recommended as mill additions for the ground coats.

Excessive additions of any one flux were not desirable, and best results were obtained when sodium, lead and boric oxides were combined in more or less definite proportions. Sodium oxide in excess of about 10 per cent gave rise to blistering. Boric oxide increased the firing range of the ground coats and was preferable to lead oxide on this account, although it tended to promote crawling of ground coats high in boric oxide if they were applied somewhat heavily.

The best ground coats developed are Rg-26, 17, 1, 25 and 18.

[1] By permission of the Director, Bureau of Standards.

[2] Read before the Enamel Division, St. Louis Meeting, Feb. 28, 1922.

Cover Enamels.—Cover enamels were smelted in the usual manner. The mill additions consisted of 5 per cent of clay, 8 per cent of tin oxide, and 45 per cent of water, all based on the weight of the dry frit.

For best results, the cover enamel must be adapted to the ground coat in refractoriness. Boric acid increased the firing range of the enamels but tended to promote crawling, although this was less pronounced in the case of the more fusible compositions. Boric oxide improved the opacity when subsituted for such fluxes as sodium and lead oxides. Cryolite increased opacity but additions above 10 per cent, based on the melted weight, tended to promote crawling. Considering all factors, cover enamels R-14 11, 28, 1 and 18 gave best results.

Introduction

Wet process enameling for cast iron has become of great importance, particularly in the stove industry, within the last few years. This is undoubtedly due to the fact that small castings required for stoves can be handled in greater volume and at less cost by this process. Less skilled labor is required for manipulation and the method lends itself readily to the enameling of irregularly shaped castings.

Very little has been published regarding this method of enameling, although it has been used for some time in the manufacture of cast iron cooking ware. The literature of the American Ceramic Society lacks any reference to wet process enameling of cast iron, and the various treatises on the subject of enameling either make no reference to or are so vague in their treatment of this particular method that they are of no help to those interested in the development of suitable compositions and technique.

The strength of enamels is inversely proportional to the thickness of the coat when the properly balanced composition is used. The heavy coats of enamel as used in the dry process are apt to chip on sharp edges when subjected to impact. The wet process tends to overcome this difficulty as it is possible to apply the enamel in much thinner coats.

Two distinct types of wet process cast iron enamels are commonly used, two or three coat process in connection with the use of a ground coat, and one or two coat process without the use of a ground coat, using one composition for both coats. This paper will treat of enamels that are used in connection with a ground coat and will deal particularly with the development of white enamels.

The method is similar to that for steel enameling, as the ground or first coat is fired and allowed to cool before the cover is applied, while the dry process necessitates sieving on the dry cover before the ground coat has cooled and the return of the casting to the furnace to gloss over the enamel, thus making it impossible to fire more than a limited number of pieces at a time.

Since it was believed that ground coats were as important as the covers, the first principal work has been in the development of suitable composi-

tions for such grounds. The basis of this work consisted of a number of typical ground coats now in use for the dry process. In order to obtain an enamel of the proper fitting qualities and expansion, the above procedure was considered advisable.

In studying cover enamels the same procedure was employed, several enamels which had given good results in commercial practice when used by the dry process being selected as the basis for the studies. This work consisted of noting the effects of variation in composition and heat treatment.

In studying the three coat wet process enamels the methods of preparing the enamels and the technic employed were based on the conclusions drawn from previous preliminary studies.

Preparation of Enamels

In the preliminary study the ground coats were prepared by weighing in five pound batches, mixing thoroughly and smelting in crucibles to the same degree as that for ground coats for sheet steel. It was soon found that the ground coats prepared by this method had very poor adherence so the sintering method was resorted to. The latter gave excellent results and was adopted, therefore, in the preparation of all ground coats used in this investigation. The materials were placed in crucibles and fired in a kiln to the temperature of approximately 975°C (1775°F) over a period of two hours. Upon cooling, the frits were broken from the crucibles and crushed in a jaw crusher to a size suitable for grinding in the ball mills.

The sintering method undoubtedly prevents the volatilization of the fluxes and also results in a ground coat having greater strength than that obtained in the melting of the materials to a glass. These results have been checked with a large number of varying compositions and even in the case of the more fusible grounds the sintering method gave far better adherence, although it is quite possible that satisfactory results may be obtained in the smelting of certain compositions.

The covers were prepared in the usual way by melting, except that the customary content of tin oxide was reserved for the mill addition. The latter consisted of 8 per cent tin oxide, 5 per cent Johnson-Porter Tennessee ball clay, with the necessary amount of water to form a slip for spraying.

The cast iron specimens for test were corner fittings and oval discs used in the manufacture of enameled stoves. They made ideal samples as they had a number of curved surfaces and sharp corners which would accentuate poor adherence of the enamel. The castings were prepared for enameling by annealing at temperatures approximating 815°C (1500°F). They were then sandblasted with a mixture of about 80 per cent sand and 20 per cent crushed steel shot.

The cleaned castings were coated with the various ground coats with a light application by means of an air spray. They were then dried thoroughly and fired in an electric furnace at temperatures varying from 760° to 815°C (1400° to 1500°F). The time of firing varied from five to ten minutes depending upon the particular ground and the type of casting used. After the firing and cooling of the ground coat, they were coated with the cover enamel by spraying. The cover enamel was dried thoroughly, and it is well to emphasize at this point the necessity of thorough drying if crawling of the enamel is to be avoided. The covers were fired at 730° to 760°C (1350° to 1400°F), the time of firing varying from five to ten minutes depending on the refractoriness of the composition.

To note the working qualities of the ground coats in respect to the cover coats, especially as to adherence and texture, enamels R-1 and R-5 (in Table III) were used with each ground coat. R-1 was a medium refractory enamel while R-5 was comparatively soft.

In Table I are shown four basic ground coat compositions giving the melted weights, batch weights and mill additions for each composition. These are typical compositions of ground coats used for dry process enameling of cast iron.[1] Rg-1 is a representative of the flint type with a considerable amount of raw clay in the mill mix. Rg-2 is a combined flint and feldspar type, this ground being a fairly refractory type with small additions of clay and cobalt oxide in the mill batch. In ground Rg-3 is shown a combination of two fusible frits containing large amounts of lead oxide, both the feldspar and flint types being represented. The mill additions consist of medium quantities of clay, flint and feldspar. Ground Rg-4 differs from the other compositions in this series as it has a comparatively high content of boric acid and feldspar. The mill additions consist of a medium amount of clay and a small percentage of cobalt oxide.

Although these ground coats had given very good results when used by the dry process, it was noted that when subjected to the wet process there was considerable variation in such properties as adherence, texture, etc., both in respect to the ground coat and the cover enamel.

Apparently the best results were obtained with Rg-1. This ground coat gave fair adherence, but the most desirable feature was the comparative freedom from pinholes in the cover enamel.

Ground coat Rg-2 adhered poorly to the iron, showing that this type of ground did not have the proper physical properties to withstand the stresses, set up in cooling, without the use of a cover for protection. It also had a short firing range so that there was a tendency for the cover enamel to develop pinholes.

With ground Rg-3, fairly good results were obtained, approaching those

[1] H. F. Staley, Bureau of Standards, *Tech. Paper* **142**, p. 79–82.

of Rg-1, although there was a tendency to develop fine pinholes, especially when slightly overfired.

When the frit compositions "a" and "b" of Rg-3 were combined to give a single frit, the results differed very much. The resulting ground coat had poor adherence, showing that the physical condition of the enamel is fully as important as its chemical composition.

Ground Rg-4 had very good adherence, but had a decided tendency to form pinholes which may have been due to its fusibility as compared with the cover coats.

TABLE I

GROUND COATS FOR WET PROCESS CAST IRON ENAMELS

FRITS

Composition	Rg-1	Rg-2	Rg-3		Rg-4
			a	b	
Flint	57.4	24.5	..	42.0	..
Borax	30.2	33.3	20.5	25.3	48.3
Sodium Nitrate	5.7	..	3.6	5.1	3.5
Red Lead	6.7	3.6	22.3	27.6	1.7
Maine Feldspar	..	38.6	53.6	..	46.5
Total	100.0	100.0	100.0	100.0	100.0

MILL BATCHES

Frit	100	100	Frit a: 66.6 Frit b: 33.3	100
Flint	69	..	10	...
Clay (Johnson-Porter)	36	6	10	15
Cobalt Oxide	..	0.33	..	0.33
Maine Feldspar	..	..	16	...

Since Rg-1 with a high content of raw mill additions had fairly good adherence and the covers applied to this ground gave the best results as to texture and opacity, it was decided to study the effect of varying mill additions. Since Rg-1 contained a considerable amount of flint and clay, it was planned to study the effect of replacing the flint by feldspar and clay, and also the replacement of clay by flint and feldspar, simply retaining enough clay to float the frit. In this procedure it was hoped that a composition might be developed which would have good adherence as well as the other desired qualities. In making these substitutions, the ratio of fusibilities, as suggested for various enamel refractories by Coe[1] in his work on ground coats for cast iron, was used. Coe gives the following ratio: 40 clay equals 66 flint equals 100 feldspar, and the substitutions were made in Rg-1 on this basis.

[1] J. H. Coe, "Compositions of Commercial Ground Coats for Cast Iron Enamels," *Trans. Amer. Ceram. Soc.*, **13**, 531 (1911).

In Series 1, Table II, ground coat 1B-Rg-1 has the flint addition in the mill batch of Rg-1 replaced by clay in the ratios given by Coe. This should result in a composition with the same refractoriness as Rg-1. To the remaining members of the series, clay has been added or subtracted in units of 15.5 parts.

Table II shows very clearly that with the increase of raw additions in the mill batch the adherence is not satisfactory, except in Series 1 where several compositions with a high clay content had fair adherence. Later

TABLE II

EFFECT OF VARIATIONS IN MILL ADDITIONS

Frit Constant 100 Grams

Specimen	Clay	Flint	Feldspar	Adherence		Cover pinholes
				Ground coat	After applying cover	
1E-Rg-1	108.5	...	...	Flaked	...	..
1C-Rg-1	93.0	...	...	O. K.	O. K.	None
1B-Rg-1	77.5	...	...	O. K.	O. K.	None
1A-Rg-1	62.0	...	...	O. K.	O. K.	None
1D-Rg-1	46.5	...	...	O. K.	O. K.	Few
1F-Rg-1	31.0	...	...	O. K.	O. K.	Few
1G-Rg-1	15.5	...	...	O. K.	O. K.	Few
IIC-Rg-1	6.0	114.0	...	Flaked	...	..
IIB-Rg-1	6.0	120.0	...	Flaked	...	..
IIA-Rg-1	6.0	96.0	...	Flaked	...	..
IID-Rg-1	6.0	73.0	...	Chipped on edge	O. K.	None
IIE-Rg-1	6.0	48.0	...	Chipped on edge	O. K.	Many
IIF-Rg-1	6.0	24.0	...	O. K.	O. K.	Many
IIIC-Rg-1	6.0	...	216.0	Flaked	...	..
IIIB-Rg-1	6.0	...	180.0	Flaked	...	..
IIIA-Rg-1	6.0	...	144.0	Flaked	...	..
IIID-Rg-1	6.0	...	108.0	Flaked	...	..
IIIE-Rg-1	6.0	...	72.0	O. K.	O. K.	Few
IIIF-Rg-1	6.0	...	36.0	O. K.	O. K.	Few

these were found to be undesirable as commercial compositions because the results were not consistent over a large number of trials, there being a tendency for chipping to develop in some cases. In Series 2 and 3 with flint or feldspar substituted for clay the adherence was very poor except where the additions were small. It will, therefore, be noted that flint and feldspar are poor substitutes for clay in the mill additions for ground coats, as they evidently detract from the adherent quality of the enamel.

Since it was concluded that an excessive amount of raw material in the mill batch was detrimental to the desired results, it was decided to make

a study of the effect of variation in the composition of the frit, using 15 per cent of clay in the mill batch, approximately the maximum amount consistently giving proper adherence. Ground Rg-1 was taken as a basis for this work. The different substitutions were made within the limits of workable ground coats. The latter must necessarily have the correct physical properties to permit them to undergo three distinct firings without blistering.

The melted and batch weights of the 21 ground coats studied are given in Tables III-H and III-I.

TABLE III-A

FLINT–PbO SERIES

The Effect of Varying Flint and PbO in Ground Coats.
Constant Portion Melted 22.10,—13.57 B_2O_3, 8.43 Na_2O.
Variable Portion Melted 77.90,—Flint and PbO

Number	Melted weights		Remarks		
	Flint	PbO	Adherence	Texture	
				R-1	R-5
Rg-5	73.50	4.40	Crawled	..	..
Rg-1	69.90	8.00	Good	Good	Good
Rg-6	66.30	11.60	Good	Fair	Good
Rg-7	62.70	15.20	Good	Fair	Good

TABLE III-B

B_2O_3–PbO SERIES

The Effect of Varying B_2O_3 and PbO in Ground Coats.
Constant Portion Melted 78.43,—69.90 Flint, 8.53 Na_2O.
Variable Portion Melted 21.57,—B_2O_3 and PbO

Number	Melted weights		Remarks		
	B_2O_3	PbO	Adherence	Texture	
				R-1	R-5
Rg-16	21.57	0.00	Good	Few Pinholes	Good
Rg-17	17.57	4.00	Good	Good	Good
Rg-1	13.57	8.00	Good	Good	Good
Rg-18	9.57	12.00	Good	Good	Good

For comparison of the various compositions and their properties, it is possible to group the ground coats according to variation in the melted weights as shown in Tables III-A to III-G inclusive.

Table III-A shows the effect of replacement of quartz by lead oxide. The adherence of the ground coat apparently is benefited by the replacements noted. Rg-1 with 70 per cent of flint evidently contains the maximum amount of flint for workable ground coats. There is apparent in the study of cover coats as applied to these ground coats a tendency for the more fusible covers to give the most satisfactory enamels. The re-

fractory covers not only produce blistering of the ground coat in the firing necessary to give the covers desirable gloss and finish, but portions of the over-fused ground coat are absorbed by the cover causing black specks in the resultant enamel.

As a whole, the lead-oxide boric-oxide series (Table III-B) gave very good results. However, in Rg-16 with the replacement of all the lead oxide by boric oxide, there was a tendency of the ground coat to crawl in

TABLE III-C

Na_2O–PbO SERIES

The Effect of Varying Na_2O and PbO in Ground Coats.
Constant Portion Melted 83.47,—69.90 Flint, 13.57 B_2O_3.
Variable Portion Melted 16.53,—Na_2O and PbO

Number	Melted weights		Remarks		
	Na_2O	PbO	Adherence	Texture	
				R-1	R-5
Rg-19	16.53	0.00	Good	Many Pinholes	Many Pinholes
Rg-20	12.53	4.00	Good	Few Pinholes	Few Pinholes
Rg-1	8.53	8.00	Good	Good	Good
Rg-21	4.53	12.00	Good	Few Pinholes	Good

TABLE III-D

FLINT–FELDSPAR SERIES

The Effect of Varying Flint and Feldspar in Ground Coats.
Constant Portion Melted 30.10,—13.57 B_2O_3, 8.53 Na_2O, 8.0 PbO.
Variable Portion Melted 69.90,—Flint and Feldspar

Number	Melted weights		Remarks		
	Flint	Feldspar	Adherence	Texture	
				R-1	R-5
Rg-1	69.90	...	Good	Good	Good
Rg-9	...	104.8	Poor	....	....
Rg-10	34.90	52.40	Poor	....	....
Rg-11	...	87.40	Poor	....	....
Rg-12	34.90	43.65	Fair	Pinhole	Pinhole
Rg-13	...	69.90	Good	Pinhole	Pinhole
Rg-14	34.90	34.90	Good	Pinhole	Pinhole

firing and for the boric acid to crystallize from the enamel if the latter was not used very soon after milling. The crawling is undoubtedly due to the higher viscosity imparted by excessive boric oxide. This, with the crystallization noted, would indicate an excess of boric oxide in the enamel. Replacing lead oxide with sodium oxide (Table III-C) gave compositions which had a decided tendency to develop pinholes.

Table III-D shows the effect of replacing flint by feldspar. In Rg-9 and 10 the ratio of three parts of feldspar to two parts of flint was adopted.

This was the relation of feldspar to flint suggested by Staley[1] for cast iron enamels. In Rg-9 all the flint was replaced by feldspar, and in Rg-10 half of the flint was replaced by feldspar. However, it was noted that replacements in this ratio increased the refractoriness and resulted in a ground coat of poor adherence. The ratio of five to four was employed in replacing the flint by feldspar in Rg-11 and 12, and one to one in Rg-13 and 14. Although these compositions possessed the desired fusibility, there was a decided tendency for the cover enamels applied to the ground to form pinholes. The feldspar, because of its alumina content, would undoubtedly

TABLE III-E

Na_2O–FLINT SERIES

The Effect of Varying Na_2O and Flint in Ground Coats.
Constant Portion Melted 21.57,—13.57 B_2O_3, 8.00 PbO.
Variable Portion Melted 78.43,—Na_2O and Flint

Number	Melted weights		Remarks		
	SiO_2	Na_2O	Adherence	Texture	
				R-1	R-5
Rg-1	69.90	8.53	Good	Good	Good
Rg-22	65.90	12.53	Good	Many pinholes	Many pinholes
Rg-23	61.90	16.53	Good	Many pinholes	Many pinholes

TABLE III-F

B_2O_3–Na_2O SERIES

The Effect of Varying B_2O_3 and Na_2O in Ground Coats.
Constant Portion Melted 77.90,—69.90 Flint, 8.00 PbO.
Variable Portion Melted 22.10,—B_2O_3 and Na_2O

Number	Melted weights		Remarks		
	B_2O_3	Na_2O	Adherence	Texture	
				R-1	R-5
Rg-1	13.57	8.53	Good	Good	Good
Rg-24	17.57	4.53	Good	Few pinholes	Good
Rg-25	9.57	12.53	Good	Good	Few pinholes

increase the viscosity of the ground coats and might account for the tendency of these compositions high in feldspar to form pinholes.

Increasing sodium oxide at the expense of flint gave poor results, as the ground coat showed many pinholes (Table III-E). This also resulted in unsatisfactory covers. For this type of ground coat, it was evident that the limit for sodium oxide is between 8.5 and 12.5 per cent.

When boric oxide was replaced by sodium oxide (Table III-F) there was some slight formation of pinholes but fairly good results were obtained with the more refractory covers.

[1] Bur. of Standards, *Tech. Paper* **142**, p. 22.

In replacing flint by boric oxide, as in Table III-G, little change was noted, the results corresponding very closely to Rg-1. Excessive boric acid, however, tended to slightly increase the number of pinholes.

Excessive addition of raw materials to the mill batch is to be discouraged. Clay and flint as mill additions give the best results although the limits for these are fairly low. Such additions as 15 per cent of clay or 10 per cent each of clay and flint should give most satisfactory results.

Sintering of the ground coats is recommended, since melting of the materials to a glass weakens the resultant ground coat.

TABLE III-G

B_2O_3-FLINT SERIES

The Effect of Varying B_2O_3 and Flint in Ground Coats.
Constant Portion Melted 16.53,—8.53 Na_2O, 8.00 PbO.
Variable Portion Melted 83.47,—B_2O_3 and Flint

Number	Melted weights		Remarks		
	SiO_2	B_2O_3	Adherence	Texture	
				R-1	R-5
Rg-1	69.90	13.57	Good	Good	Good
Rg-26	66.90	17.17	Good	Few Pinholes	Good
Rg-27	62.70	20.77	Good	Few Pinholes	Few Pinholes

TABLE III-H

GROUND COATS OF SERIES III

Melted Compositions

Enamel	Flint	Feldspar	B_2O_3	Na_2O	PbO
Rg-1	69.90	...	13.57	8.53	8.00
Rg-5	73.50	...	13.57	8.53	4.40
Rg-6	66.30	...	13.57	8.53	11.60
Rg-7	62.70	...	13.57	8.53	15.20
Rg-9	...	104.8	13.57	8.53	8.00
Rg-10	34.90	52.4	13.57	8.53	8.00
Rg-11	...	87.40	13.57	8.53	8.00
Rg-12	34.90	44.00	13.57	8.53	8.00
Rg-13	...	69.90	13.57	8.53	8.00
Rg-14	34.90	34.95	13.57	8.53	8.00
Rg-16	69.90	...	21.57	8.53	0.00
Rg-17	69.90	...	17.57	8.53	4.00
Rg-18	69.90	...	9.57	8.53	12.00
Rg-19	69.90	...	13.57	16.53	0.00
Rg-20	69.90	...	13.57	12.53	4.00
Rg-21	69.90	...	13.57	4.53	12.00
Rg-22	65.90	...	13.57	12.53	8.00
Rg-23	61.90	...	13.57	16.53	8.00
Rg-24	69.90	...	17.57	4.53	8.00
Rg-25	69.90	...	9.57	12.53	8.00
Rg-26	66.30	...	17.17	8.53	8.00
Rg-27	62.70	...	20.77	8.53	8.00

TABLE III-I

GROUND COATS OF SERIES III

Batch Compositions

Enamel	Flint	Feldspar	Borax	Sodium nitrate	Soda ash	Red lead	Boric acid
Rg-1	69.90	...	36.96	6.95	..	8.17	...
Rg-5	70.32	...	46.75	..	..	5.01	...
Rg-6	66.30	...	36.96	6.95	..	11.84	...
Rg-7	62.70	...	36.96	6.95	..	15.51	...
Rg-9	...	104.80	36.96	6.95	..	8.17	...
Rg-10	34.90	52.4	36.96	6.95	..	8.17	...
Rg-11	...	87.40	36.96	6.95	..	8.17	...
Rg-12	34.90	44.00	36.96	6.95	..	8.17	...
Rg-13	...	69.90	36.96	6.95	..	8.17	...
Rg-14	34.90	34.90	36.96	6.95	..	8.17	...
Rg-16	69.90	...	36.96	6.95	..	..	14.16
Rg-17	69.90	...	36.96	6.95	..	4.08	7.08
Rg-18	69.90	...	26.07	6.95	3.04	12.24	...
Rg-19	69.90	...	36.96	6.95	13.67	..	...
Rg-20	69.90	...	36.96	6.95	6.84	4.08	...
Rg-21	69.90	...	12.34	6.95	..	12.24	16.00
Rg-22	65.90	...	36.96	6.95	6.84	8.17	...
Rg-23	61.95	...	36.96	6.95	13.67	8.17	...
Rg-24	69.90	...	12.34	6.95	..	8.17	23.06
Rg-25	69.90	...	26.07	6.95	9.88	8.17	...
Rg-26	66.30	...	36.96	6.95	..	8.17	6.37
Rg-27	62.70	...	36.96	6.95	..	8.17	12.75

Excessive additions of any one flux were not desirable, and the best results were obtained when sodium, lead and boric oxides were combined in their proper proportions. Sodium oxide in excess of about 10 per cent, on the basis of melted weights, gave rise to blistering. Boric oxide increased the firing range of the ground coats and was preferable to lead oxide in this respect, although it tended to promote crawling of those ground coats high in boric oxide if they were applied somewhat heavily.

The best ground coats, considering both adherence of the enamel and texture of the cover coats, named in order, were Rg-26, 17, 1, 25, and 18.

Cover Enamels

In view of the results obtained with the cover enamels applied to the various ground coats, it was decided to make a study of the effect of varying composition in cover enamels. In order to bring out the relation of the ground coats and cover coats, the latter were applied to each of three different types of ground coats, namely: a high lead, a medium lead, and a leadless type, or Rg-7, Rg-1, and Rg-16, in the latter all of the lead oxide being replaced by boric oxide. As in the ground coats the replacement of one oxide by another was adopted.

In varying the compositions it was intended to bring out definitely the effect of the various constituents on adherence of the ground coat as well as the relation of the latter to the texture and opacity of the cover enamels. In the study of the ground coats certain defects developed upon the application of cover coats which apparently were not adapted to the particular ground coats; these consisted mainly of black specks, lack of gloss and small incipient pinholes. The black specks had the appearance of dirt or impurities which might have been present in the raw material or which might have been collected in the preparation of the enamel, but this evidently was not the case as the trouble was avoided when the same compositions were used by the dry process. Therefore, it was believed that the specking was due to the longer time required in melting down the covers by the wet process whereby the ground coat became overfired and small particles of it would be dissolved by the cover, resulting in dark specks.

Open pinholes on the surface of the enamels could in most cases be healed over by increasing the length of firing, but it was observed that there still remained small incipient pinholes in the covers and it was impossible to entirely eliminate this defect. The lack of opacity in these cover enamels was caused by solution of the opacifying agents and volatilization of the fluorides. This naturally would be expected to occur when an unreasonable length of time of firing was required to obtain the desired texture as compared with the time for fusing these cover coats when used in the dry process.

It was therefore evident that in order to obtain desirable results it would be necessary to accept several basic compositions and make such substitutions in these as might be expected to develop commercial enamels.

As a basis for this work two types of enamel were chosen, R-1, a medium refractory composition, and R-7, which was comparatively fusible. All cover enamels were smelted in the usual way and the frit was milled with 5 per cent of Johnson-Porter clay, 8 per cent tin oxide, and 45 per cent of water.

Cover R-1 was a rather refractory enamel containing feldspar and quartz, but comparatively low in boric oxide, while R-7 was a more fusible composition, containing feldspar and a high content of boric oxide but no quartz. These compositions were also selected to bring out any relation between ground coats and cover enamels, that is, whether a high boric oxide type could be expected to give better results with a ground coat high in boric oxide.

In Tables IV-E and IV-F and Tables V-F and V-G are shown the melted and batch weights of the compositions studied. These compositions can be grouped in series showing definite variations in composition as shown in Tables IV-A to IV-D for enamels R-8 to 19, based on R-1; and Tables V-A to V-E for enamels R-20 to 35, which are based on R-7.

The compositions based on R-1 have flint, sodium oxide, zinc oxide, and fluorspar constant, since these were present in amounts usually required for satisfactory cover enamels. The flint was not replaced as the refractoriness was varied in the different compositions by replacing the feldspar. Six per cent of zinc oxide in a composition is about the usual amount contained in cast iron cover enamels. An increase of this amount would induce crawling, while decreasing it would lessen the opacity of the enamel. An excessive amount of sodium oxide in covers produced pinholes. Sufficient sodium oxide was reserved in each composition to give about 5 per cent of sodium nitrate in the batch, which is necessary to prevent reduction of the lead compounds. The maximum amount of fluorspar usually added in cast iron covers is about 6 per cent.

TABLE IV-A

(FELDSPAR–B_2O_3) SERIES

The Effect of Varying Feldspar and B_2O_3 in White Cover Enamels.
Constant Portion Melted 53,—12 SiO_2, 8.5 Na_2O, 6 ZnO, 5.5 CaF_2, 5 Cryolite.
Variable Portion Melted 47,—Feldspar and B_2O_3

Enamel	Melted weights		Remarks					
	Feldspar	B_2O_3	Rg-1		Rg-7		Rg-16	
			Texture	Opacity	Texture	Opacity	Texture	Opacity
R-1	38.0	9.0	Good	Good	Good	Good	Good	Good
R-8	33.0	14.0	Good	Good	Good	Good	Good	Good
R-9	28.0	19.0	Slight crawling	Good ...	Slight crawling	Fair ...	Slight crawling	Good ...
R-10	23.0	24.0	Badly crawled	... ...	Badly crawled	... ...	Badly crawled	... ...

For the reasons stated above, the compounds of sodium oxide, zinc oxide and fluorspar in the compositions based on R-7 were not varied, and since lead oxide and boric oxide were the principal fluxes, it was not thought necessary to vary the amount of barium oxide.

As shown in Table IV-A with boric oxide increased at the expense of feldspar, the results were not very favorable because of the decided tendency of the enamel to crawl or bead. An increase of 5 per cent of boric oxide, over that for R-1, as in R-8, gave results similar to R-1. Although the enamel did not show any tendency to crawl, the incipient pinholes were not entirely avoided. Further increases in boric oxide improved the texture of the enamel but increased the tendency to crawling when applied in a sufficiently heavy coat to give the desired opacity. In cover R-10 the crawling was so increased that the enamel failed to cover the casting properly.

It will be noted that in lowering the refractoriness of the enamels by increasing the boric oxide, the pinholes became fewer when these covers

were applied to the more fusible ground coats. The opacity was also improved but some crawling occurred. From these results it was decided that 14 per cent of boric oxide was practically the limit in this particular type of composition in order to produce an enamel of the proper working qualities.

The effect of increasing lead oxide at the expense of feldspar, as noted in Table IV-B, gave some very interesting and instructive results which show more definitely the relation between cover enamels and the different types of ground coats. The data indicated the most suitable cover compositions for each individual ground and appeared to support the assumption made in the preliminary study of this investigation. These compositions on the whole gave very good results. However, it was noted that certain samples were not satisfactory owing to the appearance of black specks and the lack of opacity.

TABLE IV-B

(FELDSPAR–PbO) SERIES

The Effect of Varying Feldspar and PbO in White Cover Enamels.
Constant Portion Melted 46,—12 SiO_2, 9 B_2O_3, 8.5 Na_2O, 6 ZnO, 5.5 CaF_2, 5 Cryolite.
Variable Portion Melted 54,—Feldspar and PbO

Enamel	Melted weights		Remarks					
	Feld-spar	PbO	Rg-1		Rg-7		Rg-16	
			Texture	Opacity	Texture	Opacity	Texture	Opacity
R-1	38.0	16.0	Good	Good	Good	Good	Good	Good
R-11	33.0	21.0	Good	Good	Few pin-holes	Good	Black specks	Good
R-12	28.0	26.0	Good	Good	Few pin-holes	Fair	Black specks	Good
R-13	23.0	31.0	Few pin-holes	Fair	Few pin-holes	Fair	Many pinholes	Fair

It was indicated that varying results could be expected with a particular cover coat, depending on the properties of the ground coat to which it might be applied. It will, therefore, be necessary, in discussing the results obtained with the cover coats, to consider the ground coats which had been used.

The best results obtained with R-11 containing 21 per cent of lead oxide were in connection with Rg-1 ground coat. This combination appeared to give consistent results on a number of trials requiring apparently the same length of time to melt it down. The same cover with Rg-7 and 16 showed a tendency to form pinholes and to develop black specks which was probably due to the ground over-firing before the cover had matured. Cover enamel R-12 containing 26 per cent of lead oxide gave very good results with both Rg-1 and 16, but no improvement over the combination of cover R-1 and ground Rg-1 could be observed.

Covers R-11 or 12 in connection with the use of ground Rg-1 gave practically the same results with the exception of a slight decrease of opacity in R-12. With 31 per cent of lead oxide, as in R-13, pinholes were encountered, this cover giving best results with ground Rg-7. With ground Rg-1 a few pinholes were observed.

The data given above show that the covers should be fusible enough to flow down sufficiently regardless of the composition of the ground coat. An excessive amount of lead oxide in the cover coats used on medium-hard ground coats results in pinholes. It was believed that the fusion point of ground coats and cover enamels should bear a close relation to each other, the best results being obtained when the ground was slightly the more refractory of the two.

TABLE IV-C

B_2O_3–PbO SERIES

The Effect of Varying B_2O_3 and PbO in White Cover Enamels.
Constant Portion Melted 75,—38 Feldspar, 12 SiO_2, 8.5 Na_2O, 6 ZnO, 5.5 CaF, 5 Cryolite.
Variable Portion Melted, 25,—B_2O_3 and PbO

Enamel	Melted weights		Remarks					
	B_2O_3	PbO	Rg-1		Rg-7		Rg-16	
			Texture	Opacity	Texture	Opacity	Texture	Opacity
R-14	4.0	21.0	Good	Good	Good	Good	Good	Good
R-1	9.0	16.0	Good	Good	Good	Good	Good	Good
R-15	14.0	11.0	Good	Good	Good	Good	Black specks	Good
R-16	19.0	6.0	Slight crawling	Good	Slight crawling	Good	Slight crawling	Good
R-17	24.0	1.0	Crawled	Good	Crawled	Good	Crawled	Good

The results obtained in replacing lead oxide by boric oxide (Table IV-C) were not as satisfactory as in the previous series. This variation maintained the refractoriness of the composition practically constant. The results showed clearly that neither of the two fluxes could be eliminated in the composition as each gave certain necessary fusible properties in the enamel. In R-14, with 5 per cent of boric oxide replaced by lead oxide, little difference in opacity was noted between it and R-1. This enamel had a good texture and consistent results were obtained with a number of samples. It was apparent that the effect of replacing boric oxide with lead oxide was more satisfactory than that of replacing feldspar by lead oxide as the elasticity of the enamel was increased, permitting the application of a heavier coat. With the increase of boric oxide, crawling increased. In R-15, where 5 per cent of lead oxide was replaced by boric oxide, good results were obtained with Rg-1, the enamel having good

texture and opacity. This change slightly increased the refractoriness of the cover and offers further evidence that the melting points of both compositions should be about the same, because R-15 with both Rg-7 and Rg-16 had a decided tendency to produce black specks. Very poor results were obtained with both R-16 and R-17 in connection with the use of the three different ground coats. Crawling was increased in proportion to the increase of boric oxide. In order to prevent crawling with these enamels it would be necessary to apply it so thin that the opacity would be lacking.

As shown in Table IV-D, where feldspar was replaced by cryolite, the results obtained were very satisfactory considering both texture and opacity. The advantage of replacing feldspar by cryolite over the re-

TABLE IV-D

FELDSPAR–CRYOLITE SERIES

The Effect of Varying Feldspar and Cryolite in White Cover Enamels. Constant Portion Melted 57,—12 SiO_2, 9 B_2O_3, 8.5 Na_2O, 16 PbO, 6 ZnO, 5.5 CaF_2. Variable Portion Melted 43,—Feldspar and Cryolite

Enamel	Melted weights		Remarks					
	Feld-spar	Cryo-lite	Rg-1		Rg-7		Rg-16	
			Texture	Opacity	Texture	Opacity	Texture	Opacity
R-1	38.0	5.0	Good	Good	Good	Good	Good	Good
R-18a	35.5	7.5	Good	Good	Good	Good	Good	Good
R-18	33.0	10.0	Good	Very good	Good	Very good	Good	Good
R-19a	30.5	12.5	Good	Very good	Good	Very good	Black specks	Good
R-19	28.0	15.0	Good	Very good	Good	Very good	Black specks	Good

placement of feldspar by lead oxide was the increase of opacity as well as the fusibility of the composition. Replacing 5 per cent of the feldspar by cryolite gave very good results with the three different types of ground coats, but when 10 per cent of feldspar was replaced by cryolite the results were not so favorable, pinholes being apparent in the covers used with both Rg-1 and Rg-16. Aside from this feature, it was noted that this enamel had a slight tendency to crawl when applied rather heavily. R-18a, with 7.5 per cent of feldspar replaced by cryolite, gave results similar to those of R-18, while in R-19a, with 12.5 per cent of feldspar replaced by cryolite, the same trouble was incurred as in R-19 with a further increase of cryolite to 15 per cent.

The above results indicate that cryolite should not exceed 10 per cent to give the most satisfactory results in cover enamels of this type.

When using R-7 as a basic composition the results obtained by the

various substitutions were not as satisfactory in their entirety as those in the previous series because of the lack of opacity. However, several good compositions were developed, and the work shows definitely the different effects on cover enamels of this type when the same substitutions are made as in the previous series. As the basic composition R-7 was

TABLE IV-E

WHITE COVER ENAMELS OF SERIES IV

Melted Compositions

Enamel	Feldspar	Flint	B_2O_3	Na_2O	PbO	ZnO	CaF_2	Cryolite
R-1	38.0	12.0	9.0	8.5	16.0	6.0	5.5	5.0
R-8	33.0	12.0	14.0	8.5	16.0	6.0	5.5	5.0
R-9	28.0	12.0	19.0	8.5	16.0	6.0	5.5	5.0
R-10	23.0	12.0	24.0	8.5	16.0	6.0	5.5	5.0
R-11	33.0	12.0	9.0	8.5	21.0	6.0	5.5	5.0
R-12	28.0	12.0	9.0	8.5	26.0	6.0	5.5	5.0
R-13	23.0	12.0	9.0	8.5	31.0	6.0	5.5	5.0
R-14	38.0	12.0	4.0	8.5	21.0	6.0	5.5	5.0
R-15	38.0	12.0	14.0	8.5	11.0	6.0	5.5	5.0
R-16	38.0	12.0	19.0	8.5	6.0	6.0	5.5	5.0
R-17	38.0	12.0	24.0	8.5	1.0	6.0	5.5	5.0
R-18	33.0	12.0	9.0	8.5	16.0	6.0	5.5	10.0
R-19	28.0	12.0	9.0	8.5	16.0	6.0	5.5	15.0
R-18a	35.0	12.0	9.0	8.5	16.0	6.0	5.5	7.5
R-19a	30.5	12.0	9.0	8.5	16.0	6.0	5.5	12.5

TABLE IV-F

WHITE COVER ENAMELS OF SERIES IV

Batch Compositions

Enamel	Feldspar	Flint	Borax	Sodium nitrate	Soda ash	Red lead	Zinc oxide	Fluorspar	Cryolite	Boric acid
R-1	38.0	12.0	24.52	6.20	3.86	16.42	6.0	5.5	5.0	...
R-8	33.0	12.0	38.14	6.35	..	16.42	6.0	5.5	5.0	...
R-9	28.0	12.0	38.14	6.35	..	16.42	6.0	5.5	5.0	8.85
R-10	23.0	12.0	38.14	6.35	..	16.42	6.0	5.5	5.0	17.70
R-11	33.0	12.0	24.52	6.20	3.86	21.60	6.0	5.5	5.0	...
R-12	28.0	12.0	24.52	6.20	3.86	26.70	6.0	5.5	5.0	...
R-13	23.0	12.0	24.52	6.20	3.86	31.80	6.0	5.5	5.0	...
R-14	38.0	12.0	10.90	6.20	7.70	21.60	6.0	5.5	5.0	...
R-15	38.0	12.0	38.14	6.35	..	11.30	6.0	5.5	5.0	...
R-16	38.0	12.0	38.14	6.35	..	6.20	6.0	5.5	5.0	8.85
R-17	38.0	12.0	38.14	6.35	..	1.03	6.0	5.5	5.0	17.75
R-18	33.0	12.0	38.14	6.20	3.86	16.42	6.0	5.5	5.0	...
R-19	28.0	12.0	24.52	6.20	3.86	16.42	6.0	5.5	5.0	...
R-18a	35.5	12.0	24.52	6.20	3.86	16.42	6.0	5.5	5.0	...
R-19a	30.5	12.0	24.52	6.20	3.86	16.42	6.0	5.5	5.0	...

considerably more fusible than R-1, the results with enamels in which the feldspar content remained constant or was increased, proved more favorable than where feldspar was decreased below that percentage in the base enamel.

In R-20, increasing the feldspar 5 per cent at the expense of boric oxide, as in Table V-A, good results were obtained with grounds Rg-1 and 7 although the opacity was not exceptionally good in either case. There

TABLE V-A

FELDSPAR–B_2O_3 SERIES

The Effect of Varying Feldspar and B_2O_3 in White Cover Enamels.
Constant Portion Melted 40,—11 Na_2O, 15 PbO, 5 ZnO, 3.5 BaO, 5.5 CaF_2.
Variable Portion Melted 60,—Feldspar and B_2O_3

Enamel	Melted weights		Remarks					
	Feld-spar	B_2O_3	Rg-1		Rg-7		Rg-16	
			Texture	Opacity	Texture	Opacity	Texture	Opacity
R-21	50.0	10.0	Good	Fair	Good	Fair	Good	Fair
R-20	45.0	15.0	Good	Fair	Good	Fair	Good	Fair
R-7	40.0	20.0	Good	Fair	Good	Fair	Good	Good
R-22	35.0	25.0	Black specks	Poor	Good	Fair	Black specks	Poor

TABLE V-B

FELDSPAR–PbO SERIES

The Effect of Varying Feldspar and PbO in White Cover Enamels.
Constant Portion Melted 45,—20 B_2O_3, 11 Na_2O, 5 ZnO, 3.5 BaO, 5.5 CaF_2.
Variable Portion Melted 55,—Feldspar and PbO

Enamel	Melted weights		Remarks					
	Feld-spar	PbO	Rg-1		Rg-7		Rg-16	
			Texture	Opacity	Texture	Opacity	Texture	Opacity
R-24	50.0	5.0	Good	Fair	Good	Fair	Good	Fair
R-23	45.0	10.0	Good	Fair	Good	Fair	Good	Fair
R-7	40.0	15.0	Good	Fair	Good	Fair	Good	Fair
R-25	35.0	20.0	Good	Poor	Good	Poor	Good	Poor
R-26	30.0	25.0	Good	Poor	Good	Poor	Good	Poor
R-27	25.0	30.0	Good	Poor	Good	Poor	Good	Poor

was a slight improvement over R-7. Increasing the feldspar 10 per cent at the expense of the boric oxide gave good results with the three different types of ground coats. The opacity was not improved over R-20 and in certain samples there was a tendency to form black specks, the latter fact indicating that the cover was too refractory for the different ground coats. Increasing the boric oxide 5 per cent at the expense of feldspar, as in cover R-22, affected the properties of the composition as might be expected from the results obtained from R-20 and R-21. This cover used with Rg-1 and 16 had poor texture and opacity. In both cases

many black specks were apparent. When used with Rg-7 the texture was free from black specks but the opacity was not improved. Apparently the best combination obtained from this study was R-20 used in connection with ground Rg-1.

In Table V-B is shown a series with lead oxide replaced by feldspar and feldspar replaced by lead oxide. The results obtained were fairly satisfactory as to texture, but opacity was lacking throughout the whole series. With these various substitutions Rg-1 appeared to be the most suitable ground coat. Increasing the lead oxide bettered the texture with covers applied on ground Rg-1; however, a decrease of opacity was noticed as the lead oxide was increased.

TABLE V-C

PbO–B_2O_3 SERIES

The Effect of Varying PbO and B_2O_3 in White Cover Enamels.
Constant Portion Melted 65,—40 Feldspar, 11 Na_2O, 5 ZnO, 3.5 BaO, 5.5 CaF_2.
Variable Portion Melted 35,—PbO and B_2O^3

Enamel	Melted weights		Remarks					
	B_2O_3	PbO	Rg-1		Rg-7		Rg-16	
			Texture	Opacity	Texture	Opacity	Texture	Opacity
R-28	25.0	10.0	Good	Good	Good	Good	Good	Good
R-7	20.0	15.0	Good	Fair	Good	Fair	Good	Good
R-29	15.0	20.0	Good	Fair	Good	Fair	Black specks	Good
R-30	10.0	25.0	Good	Fair	Few pinholes	Fair	Few pinholes	Fair
R-31	5.0	30.0	Many pinholes	Fair	Many pinholes	Fair	Many pinholes	Fair

Replacing 5 per cent of lead oxide with feldspar gave an enamel having good texture with either of the three types of grounds, but in each case opacity was lacking. Increasing feldspar 10 per cent at the expense of lead oxide further increased the opacity and there was considerable formation of pinholes when these cover enamels were used over the softer grounds.

Replacing the feldspar by lead oxide gave rather poor results with Rg-7 and 16, pinholes being formed with each step and the opacity decreasing proportionally with the increase of lead oxide. However, it was noted that the same composition used with Rg-1 gave enamels with fairly good texture.

From the data given above it was decided that a high content of lead oxide decreased the opacity of the enamel. Cover R-23 when used with ground Rg-1 apparently gave the best results of any enamel in this series.

Replacing lead oxide by boric oxide (Table V-C) produced enamels having more desirable properties than those obtained in the previous series

based on Cover R-7. It was noted that the opacity could be controlled more successfully by varying the proportion of the fluxes.

The most satisfactory composition developed in this series was R-28. The properties of this enamel were such that good results were obtained with the three different types of grounds.

Cover R-28 contains 25 per cent of boric oxide. This amount is unusually high, but for this particular type of enamel a high boric oxide con-

TABLE V-D

FELDSPAR–CRYOLITE SERIES

The Effect of Varying Feldspar and Cryolite in White Cover Enamels.
Constant Portion Melted 60,—20 B_2O_3, 11 Na_2O, 15 PbO, 5 ZnO, 3.5 BaO, 5.5 CaF_2.
Variable Portion Melted 40,—Feldspar and Cryolite

Enamel	Melted weights		Remarks					
	Feldspar	Cryolite	Rg-1		Rg-7		Rg-16	
			Texture	Opacity	Texture	Opacity	Texture	Opacity
R-7	40.0	...	Good	Fair	Good	Fair	Good	Good
R-32	35.0	5.0	Fine pinholes	Fair	Black specks	Poor	Good	Poor
R-33	30.0	10.0	Crawled Few pinholes	Poor	Crawled Many pinholes	Poor	Crawled Black specks	Poor

TABLE V-E

B_2O_3–CRYOLITE SERIES

The Effect of Varying B_2O_3 and Cryolite in White Cover Enamels.
Constant Portion Melted 80,—40 Feldspar, 11 Na_2O, 15 PbO, 5 ZnO, 3.5 BaO, 5.5 CaF_2.
Variable Portion Melted 20,—B_2O_3 and Cryolite

Enamel	Melted weights		Remarks					
	B_2O_3	Cryolite	Rg-1		Rg-7		Rg-16	
			Texture	Opacity	Texture	Opacity	Texture	Opacity
R-7	20.0	..	Good	Fair	Good	Fair	Good	Good
R-34	15.0	5.0	Good	Fair	Crawled	Fair	Few pinholes	Fair
R-35	10.0	10.0	Many pinholes	Poor	Few pinholes	Poor	Few pinholes	Poor

tent produced the most beneficial results. However, it was noted that more care was required in the manipulation, as a composition of this kind is more liable to crawl than the lead type. Increasing the lead oxide at the expense of boric oxide, as in covers R-29, 30 and 31, produced enamels with lower viscosity, but with many of the samples pinholes and black specks were formed, these features being noticeable when either of the three types of ground coats was used. The opacity was decidedly decreased with the increase of lead oxide and with increase of 15 per cent the enamel approached a clear glass.

The replacement of feldspar by cryolite (Table V-D) in this type of enamel did not prove very successful. The most serious objection was crawling, while the texture and opacity were not improved to any noticeable extent.

The fact that cryolite had vastly different effects in the two different types of basic enamels shows rather definitely that a broad statement cannot be made as to its effect in different types of compositions.

The lack of opacity in these enamels containing cryolite may be due to the fusibility of the enamel, probably allowing easy volatilization of the fluorine and solution of the opacifying agents.

It was also noted that in increasing cryolite at the expense of feldspar and boric oxide, crawling of the enamel occurred.

The replacement of boric oxide by cryolite (Table V-E) as in R-34 and 35, gave results which were very similar to those obtained with R-32 and 33. These enamels had a decided tendency to crawl and the texture was not satisfactory when either composition was used with the three different types of ground coats.

It will be noted that vastly different results were obtained varying by the same constituents in the composition of R-1 and R-7. The most appreciable difference was noted when the effect of cryolite in these compositions was studied. The same amount of boric oxide in the two compositions gave decidedly different results. It is evident that the limit for boric oxide is higher in the case of the more fusible enamels. This may

TABLE V-F

WHITE COVER ENAMELS OF SERIES V

Melted Compositions

Enamel	Feldspar	B_2O_3	Na_2O	PbO	ZnO	BaO	CaF_2	Cryolite
R-7	40.0	20.0	11.0	15.0	5.0	3.5	5.5	..
R-20	45.0	15.0	11.0	15.0	5.0	3.5	5.5	..
R-21	50.0	10.0	11.0	15.0	5.0	3.5	5.5	..
R-22	35.0	25.0	11.0	15.0	5.0	3.5	5.5	..
R-23	45.0	20.0	11.0	10.0	5.0	3.5	5.5	..
R-24	50.0	20.0	11.0	5.0	5.0	3.5	5.5	..
R-25	35.0	20.0	11.0	20.0	5.0	3.5	5.5	..
R-26	30.0	20.0	11.0	25.0	5.0	3.5	5.5	..
R-27	25.0	20.0	11.0	30.0	5.0	3.5	5.5	..
R-28	40.0	25.0	11.0	10.0	5.0	3.5	5.5	..
R-29	40.0	15.0	11.0	20.0	5.0	3.5	5.5	..
R-30	40.0	10.0	11.0	25.0	5.0	3.5	5.5	..
R-31	40.0	5.0	11.0	30.0	5.0	3.5	5.5	..
R-32	35.0	20.0	11.0	15.0	5.0	3.5	5.5	5.0
R-33	30.0	20.0	11.0	15.0	5.0	3.5	5.5	10.0
R-34	40.0	15.0	11.0	15.0	5.0	3.5	5.5	5.0
R-35	40.0	10.0	11.0	15.0	5.0	3.5	5.5	10.0

TABLE V-G

WHITE COVER ENAMELS OF SERIES V

Batch Compositions

Enamel	Feldspar	Borax	Sodium nitrate	Soda ash	Red lead	Zinc oxide	Barium carb.	Fluorspar	Cryolite	Boric acid
R-7	40.0	24.52	5.95	..	15.40	5.0	4.5	5.5	..	..
R-20	45.0	41.0	5.95	3.73	15.4	5.0	4.5	5.5	..	..
R-21	50.0	27.3	5.95	7.55	15.4	5.0	4.5	5.5	..	8.85
R-22	35.0	54.5	5.95	..	15.4	5.0	4.5	5.5	..	..
R-23	45.0	54.5	5.95	..	10.3	5.0	4.5	5.5	..	..
R-24	50.0	54.5	5.95	..	5.15	5.0	4.5	5.5	..	..
R-25	35.0	54.5	5.95	..	20.6	5.0	4.5	5.5	..	..
R-26	30.0	54.5	5.95	..	25.7	5.0	4.5	5.5	..	..
R-27	25.0	54.5	5.95	..	30.9	5.0	4.5	5.5	..	..
R-28	50.0	54.5	5.95	..	10.3	5.0	4.5	5.5	..	8.85
R-29	40.0	41.0	5.95	3.73	20.6	5.0	4.5	5.5	..	..
R-30	40.0	27.3	5.95	7.55	25.7	5.0	4.5	5.5	..	..
R-31	40.0	13.6	5.95	11.30	30.9	5.0	4.5	5.5	..	..
R-32	35.0	54.5	5.95	..	15.4	5.0	4.5	5.5	5.0	..
R-33	30.0	54.5	5.95	..	15.4	5.0	4.5	5.5	10.0	..
R-34	40.0	41.0	5.95	3.73	15.4	5.0	4.5	5.5	5.0	..
R-35	40.0	27.3	5.95	7.55	15.4	5.0	4.5	5.5	10.0	..

be due to the fact that the refractory enamels are comparatively viscous and this property is emphasized by the additions of such a substance as boric oxide.

The different effects in the two compositions show rather definitely that the effects of boric oxide and cryolite can be stated only in relation to a definite composition.

Summary

The primary purpose of this investigation has been to learn the effect of varying composition and treatment on wet process enamels. A number of satisfactory enamels have been developed and information has been gained regarding the technic of this type of enameling. While consideration must be given to the comparative refractoriness of the ground and cover coats, the following compositions may be mentioned as having given very satisfactory results: Ground coats Rg-26, 17, 1, 25, and 18, and cover coats R-14, 11, 28, 1, and 18. The laboratory results for the more promising enamels have been checked on a factory basis, and, taking into consideration the variations in furnace and factory conditions, the conclusions drawn from the laboratory work have been confirmed.

BUREAU OF STANDARDS
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Discussion

MR. SWEELY:—I would like to ask, if you mean crawling of the enamel before fusion or afterwards; when you first put it into the furnace?

MR. DANIELSON:—When it first goes in the furnace there is a sort of cracking of the enamel, it then peels back leaving the metal exposed. An enamel that would so crack and crawl would not be a practical ground coat to use, or in the case of cover coat it would not be satisfactory for commercial purposes.

MR. WEISTER:—How fast did you dry that enamel?

MR. DANIELSON:—That is a very important thing in connection with the use of wet process enameling. It is very important that the cover coats dry very thoroughly before they are used and dried slowly. Samples were placed in a drier at about ninety degrees and probably dried in about an hour's time, thoroughly; and for safety we then left those in an hour longer. Unless the cover compositions are dried thoroughly there would be cracking and crawling of the enamel.

The results we have obtained in that connection have also been verified in commercial practice, where wet process enamels are used. It is absolutely necessary to dry slowly and dry carefully in all cases in order to avoid cracking.

MR. MALINOVSKY:—Is not the same true also of steel enamels?

MR. DANIELSON:—It is true with sheet steel enamel, but wet process enamels on cast iron must be dried somewhat slower and much more thoroughly. One explanation of that may be that the cast iron is somewhat more porous, and, also, the moisture is retained longer in these than in sheet steel coated with a rather glassy ground coat.

THE INFLUENCE OF HEAT ON THE MICROSCOPIC PROPERTIES OF SILICA IN ITS DIFFERENT MINERAL FORMS[1]

By J. T. Robson

ABSTRACT

A study is made of the effect of heat at cone 13 and cone 14 on the index of refraction of the four common mineral forms of silica used in the ceramic industries. These mineral forms are sand, quartz, chalcedony and French flint. The effect of these mineral forms on the index of refraction of porcelain bodies fired to cone 13 and cone 14 is also given.

The inversions of silica are recognized as a source of weakness in any ceramic body into which it is introduced. The inversion temperatures for quartz have been determined with great care and are as follows:

Inversion	Temperature	Remarks[2]
A quartz–B quartz	575° C	Rapid, reversible
B quartz–B_2 tridymite	870°± 10°	Very sluggish, reversible
B tridymite–B cristobalite	1470°± 10°	Very sluggish, reversible

The different mineral forms of silica used in the ceramic industries make it of special interest to know their difference in behavior resulting from heat treatment. At the present time there are four different mineral forms of silica on the market. These are as follows:

(1) Common Potters Flint, a silica sand obtained by washing a sand rock and pulverizing the product.

(2) Rock Quartz, a massive quartz rock, called sugar quartz, which occurs as intrusions in pegmatites and granites. This rock is calcined at about 1000°C which weakens its structure and it is then pulverized.

(3) French Flint, a nodular form of silica, which occurs as pebbles along the Atlantic coast of Europe and Greenland. These pebbles are probably segregated silica from the slimes of the ocean bottom which have worked up to the shore level. The pebbles are calcined at about 1000°C which renders them friable and then easily pulverized.

(4) Chalcedony, a massive but rather easily crushed rock, occurring in considerable quantity as lens or pocket deposits in southwestern Illinois. This is crushed and pulverized.

These four mineral forms of silica were studied as they are ordinarily furnished to the ceramic industries and also after being heated to temperatures of cone 13 (1390°C) and cone 14 (1410°C). These four mineral forms of silica were also studied in porcelain bodies fired at cones 13 and 14.

Method of Procedure.—The bodies together with samples of the silicas alone were placed in an 8 inch by 8 inch circular sagger, covered and placed inside a larger sagger and burned in the load test furnace (con-

[1] Presented at the St. Louis Meeting, Feb. 28, 1922.

[2] "The Ternary System CaO–Al_2O_3–SiO_2," Rankin & Wright, *Am. J. Sci.*, **39**, 4 (1915).

pressed air-gas) to cone 13 down inside the small sagger. The time required for this burn was 4½ hours.

Another burn to cone 14 down inside the sagger was made using similar porcelain bodies and the silicas alone. The time required for this burn was 4¼ hours.

The porcelain body used had the following composition:

Canadian Feldspar	20%
Florida Kaolin	45%
Silica	35%
	100%

These bodies were made into circular discs about 3 inches in diameter by about ½ inch thick.

The body samples were pulverized to an impalpable powder in an agate mortar. The silt was removed by decantation with water and the residue examined in order to show as distinctly as possible the free silica grains not enveloped with the conglomerate body.

A 4 mm. objective was used in this work. This was especially necessary in examining the chalcedony which is micro-crystalline.

Results

TABLE I

SCREEN ANALYSIS OF DIFFERENT FORMS OF SILICA

Material	Cumulative percentage residue			
	100 m.	150 m.	200 m.	300 m.
Sand.....	0.35	0.35	1.97	4.57
Quartz.....	0.70	2.39	11.41	23.29
Chalcedony.....	0.06	0.72	1.27	1.68
French Flint.....	0.26	1.74	4.27	8.56

TABLE II

EFFECT OF HEAT ON INDEX OF REFRACTION OF DIFFERENT FORMS OF SILICA

Material	Index before heating	Index after heating to cone 13	Index after heating to cone 14
Sand.....	1.545	1.545	1.509
Quartz.....	1.545	1.545	1.517
Chalcedony.....	1.540	1.527	1.495
French Flint.....	1.527	1.487	1.487

TABLE III

INDEX OF REFRACTION OF PORCELAIN BODIES MADE WITH DIFFERENT FORMS OF SILICA

Material	Index of body fired to cone 13	Index of body fired to cone 14
Sand.....	1.522	1.508
Quartz.....	1.523	1.500
Chalcedony.....	1.512	1.502
French Flint.....	1.518	1.505

Comments.—Table II shows that both the sand and quartz before heating have an index of refraction of 1.545 which practically corresponds to 1.54425, the value given for SiO_2 by Winchell.[1]

No effect is noticed in the case of either sand or quartz on the index at cone 13, about 1390°C, but at cone 14, about 1410°C, a decided drop has taken place in the indices of both substances, showing that above cone

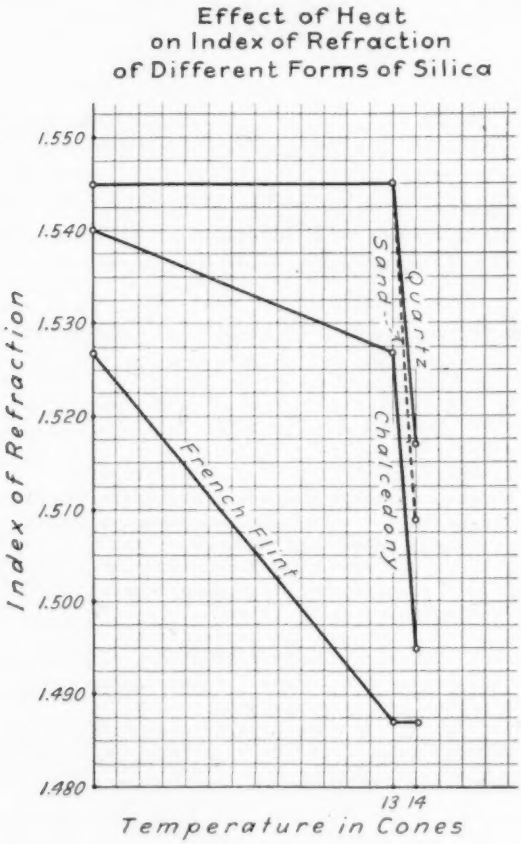

FIG. 1.

13 both sand and quartz tend to transform into cristobalite which has an index of refraction of 1.487.[2]

The French flint before heating has an index of 1.527 which is lower than that of ordinary quartz (1.545). This is due no doubt to the fact that before French flint is ground the pebbles are calcined at about 1000°C (cone 07).

[1] "Elements of Optical Mineralogy," p. 341.

[2] Rankin & Wright, *Am. J. Sci.*, **39**, 4 (1915).

At cone 13 this French flint changed entirely to cristobalite, as shown by the index 1.487. This index remained unchanged at cone 14. Since the lowest burn made was at cone 13, it is not known whether or not French flint is entirely inverted into cristobalite below cone 13.

Before heating, the index of chalcedony was 1.540, which is 0.005 below that of ordinary quartz. At cone 13, the index fell to 1.527, which is the same as that found for the French flint as received. At cone 14 the index is 1.495, which is but 0.008 greater than that for cristobalite, showing that at cone 14 the chalcedony has nearly inverted into pure cristobalite.

In general, it is to be noted that heat has a very similar effect on the index of refraction of both flint and quartz. This is shown by the attached curve A which also shows the effect of heat on the index of refraction of chalcedony and French flint.

It was found impossible to obtain the correct index of refraction of the silicas in the porcelain aggregates because the crystal could not be absolutely segregated and upon raising the body tube of the microscope the Becke line would go in on one side but out on the other.

With the bodies containing flint, quartz and French flint, many free silica crystals could be observed when the bodies were very finely ground. With the body containing chalcedony, a few white opaque crystals could be observed under crossed nicols, the same as observed with chalcedony alone under crossed nicols, tending to show that some uncombined chalcedony was present. This chalcedony body appeared to be very fine grained and not of large crystalline structure as the other three bodies.

Table III shows that the index of the various conglomerate bodies did not differ to a very great extent. Considerable difficulty was experienced in obtaining the index of these bodies because of lack of a clear definite line of light.

The quartz in the raw state, although white, was slightly darker than the other silicas. This difference in color was more intensified after heating, the quartz having a very pale straw color, whereas the other materials were extremely white. A similar effect on wetting the silicas was noted. The quartz possessed the darkest color, the French flint also had a faint dark color when wet. After the silt was decanted off, as described in the procedure, the difference in color was not nearly so intense, due probably to the fact that traces of clay were present which would be included in the silt.

Table I shows that the quartz used in this study was much coarser than the other silicas used and that the chalcedony was much finer than the others.

Since this paper was prepared a communication has been received from Dr. R. Rieke of Charlottenberg, Germany, to whom a portion of the same samples had been sent. Dr. Rieke studied the speed of transformation

into cristobalite by burning the samples to 1430°C and noting the change in their specific gravity.[1]

He obtained the following results:

TABLE IV

Material	Specific gravity before burning	Specific gravity after burning to 1430°C
Sand.....	2.67	2.49
Quartz.....	2.66	2.49
Chalcedony.....	2.66	2.32
French Flint.....	2.58	2.28

Cristobalite has a specific gravity of 2.32.

This work in agreement with the writer's work tends to show that French flint and chalcedony both transform into cristobalite before sand and quartz, which appear to alter about the same.

Table IV shows that at 1430°C chalcedony had entirely transformed into cristobalite and since, according to Table II, it had not inverted at 1410°C, the temperature of 1430°C is probably very close to the inversion temperature of chalcedony into cristobalite.

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[1] *Berichte der Deutschen Keramischen Gesellschaft,* **2,** 169 (1921).

TALC AS A FLUX FOR HIGH TENSION INSULATOR PORCELAINS[1]

By Robert Twells, Jr.[2]

ABSTRACT

MgO has some possibilities as a partial or total flux in high tension insulator porcelains. To be practical for this purpose it must be introduced into the body through some cheap material which will not make a large percentage of calcine necessary.

Talc seems to fulfill these requirements better than other sources of MgO more commonly used.

A typical high tension insulator body of the general formula 0.21 K_2O, 1.0 Al_2O_3, 4.45 SiO_2 was used as a standard. The experimental work consisted chiefly in the partial replacement of the K_2O by MgO, the RO being varied between 0.14 and 0.30 equivalents. Talc was used as the source of MgO.

The bodies were fired to temperatures ranging between cones 9 and 11 and were tested in most cases only for absorption and transverse strength.

The results at cone 10½ indicate (1) a small addition of talc greatly decreases the percentage of feldspar necessary for vitrification, (2) additional small amounts of talc have much less effect than the first small addition, (3) about 0.16 equivalents of Ro are needed for vitrification at this temperature when small percentages of talc are used. This corresponds to about 15 to 22.5% of feldspar and about 2.5% to 0.75% of talc, (4) in the properly vitrified bodies the addition of the MgO at the expense of the K_2O, within the limits tested, tends to increase the transverse strength. Vitrified bodies of this general type show little improvement, if any, over regular triaxial porcelains. The writer recommends as the next logical step a trial of the effect of the replacement of feldspar entirely or almost entirely by talc and the use of higher temperatures to obtain vitrification.

Introduction

In the literature of the American Ceramic Society there are many articles on the use of MgO in ceramic bodies. These articles cover several methods of introducing this oxide into bodies intended for different purposes. The sources of the MgO used were magnesia, fused magnesia, magnesite, dolomite, talc, or a calcine. The bodies reported may be classified on a basis of vitrification as vitreous, semi-vitreous and very porous. One of the first requirements of a high tension insulator porcelain is that it be as nearly non-porous as possible. As Barringer[3] has pointed out, experiments with improperly vitrified bodies give little information as to the effect of MgO in this type of porcelain. MgO in a porous body may have a certain effect; for example, giving good resistance to heat changes, and yet fail to give good results in a vitreous body. It is possible however, to pick several points from our literature which will indicate in a general way the effect of this oxide as an ingredient in high tension insulator porcelains.

[1] White Wares Division, St. Louis Meeting, Feb. 28, 1922.

[2] Most of the experimental work described in this article was done jointly with Mr. C. C. Lin, Research Laboratories, General Electric Company, Schenectady, New York.

[3] L. E. Barringer, *Trans. Amer. Ceram. Soc.*, **6**, 86 (1904).

1. MgO, in small amounts, lowers the maturing point of a triaxial body, but does not shorten its vitrification range as does CaO.[1]

2. In triaxial bodies not fired to vitrification, the first small additions of MgO lower the porosity most decidedly.[2] The rate decreases as the amount is increased.

3. Vitreous bodies containing MgO tend to be resistant to heat changes.[3]

4. MgO greatly accelerates the formation of sillimanite.[4]

5. The hot dielectric strength of a vitrified body composed only of MgO, Al_2O_3, and SiO_2 is much higher than that of a feldspar porcelain.[5]

6. The minimum temperature at which fluxing action would be expected in a body composed only of MgO, Al_2O_3, and SiO_2 would be cone 12 down, since this was reported by Watts as being the eutectic temperature of these three oxides.[6]

7. Watts reported highly translucent bodies at cone 13 composed only of MgO, Al_2O_3, and SiO_2.[7]

A study of these general effects of MgO in a vitreous body impresses one with its possibilities as a partial or total substitute for the K_2O in a feldspar high tension insulator porcelain. This seems especially true in view of the recent work of the Bureau of Standards on spark plug porcelain composed only of MgO, Al_2O_3, and SiO_2.[8]

As Klinefelter[9] recently pointed out, this general type of porcelain might also be superior to a good feldspar porcelain for high tension insulator use. But this remains to be proven. Feldspar porcelain insulators have been used successfully for many years under a wide variety of conditions. Feldspar, also, has the desirable properties of being simple to introduce, safe in fluxing action, and giving a relatively low maturing point to a body. On the other hand, as Klinefelter[10] also pointed out, the voltages used on high tension transmission lines are gradually being increased and there is a corresponding demand for a very superior electrical porcelain. A high tension insulator porcelain radically superior in every property to those now available can hardly be expected by the use of only feldspar, flint, and clay. If one property is improved by changing the relative percentages of these ingredients other properties will be less satisfactory. The best "all-around" triaxial bodies are

[1] F. H. Riddle and W. W. McDanel, *Jour. Amer. Ceram. Soc.*, **1**, 606 (1918).
[2] H. Hope, *Trans. Amer. Ceram. Soc.*, **11**, 494 (1909).
[3] E. T. Montgomery, *Ibid.*, **15**, 606 (1913).
[4] A. V. Bleininger and F. H. Riddle, *Jour. Amer. Ceram. Soc.*, **2**, 564 (1919).
[5] *Ibid.*
[6] A. S. Watts, *Trans. Amer. Ceram. Soc.*, **19**, 453 (1917).
[7] *Ibid.*
[8] A. V. Bleininger and F. H. Riddle, *Ibid.*
[9] T. A. Klinefelter, *The New Jersey Ceramist*, **1**, 251–67 (1921).
[10] T. A. Klinefelter, *Ibid.*

those which have been developed by compromising between the desired properties.[1]

It is, then, desirable to consider whether improvement can be attained by the total or partial replacement of the flint and feldspar by other materials. The spark plug porcelains developed by the Bureau of Standards would seem logical types towards which to experiment.

As a flux in these porcelains a calcine of the general formula X MgO Al_2O_3 Y SiO_2 is recommended. A calcine is desirable to eliminate the excessive shrinkage which would otherwise be caused by the high clay content necessary in a body in which feldspar is replaced by magnesite. This is especially true if the flint content of the body is also reduced. A body containing such a calcine could hardly be used for high tension insulators owing to the cost of mixing, pressing, pugging, firing, and grinding 50 to 60% of the materials before they could be used in the body. Unless it had extremely good properties it would be cheaper to use several strings of feldspar porcelain insulators rather than one of this type.

The commercial possibility of the use of MgO as a partial or total flux for high tension insulator porcelains depends largely on the method of introducing the MgO. The source of the MgO must not only be cheap, but it must also be in such a form as to eliminate the necessity for a large percentage of calcine. Fused MgO would be too expensive. Barringer[2] has shown some of the objections to the direct introduction of magnesia into a body. Dolomite introduces too much CaO and gives off an objectionable amount of gases in firing. Magnesite is expensive. It also gives off a large amount of gases in firing and tends to give an excessive shrinkage in a body. In common with the other possible sources mentioned, it would be necessary to calcine a large percentage of the raw materials. The most important source of MgO left to consider is talc.

Parmelee and Baldwin[3] have pointed out that the use of talc is by no means new. They investigated its effect in a body mainly from the standpoint of white ware. Purdy[4] reported that talc was undesirable as a flux for floor tile. Howat[5] reported that the eutectic between Maine feldspar and steatite was between 17½ and 22½% of steatite, and its temperature about 1215°C. Barringer[6] reported that ground talc bonded with precipitated magnesium silicate gave a high heat resistant body. Stover[7] reported that by partially substituting talc for whiting and lowering the flint content, he was able to produce a body resistant to heat shocks.

[1] G. L. Gilchrest and T. A. Klinefelter, *Elec. Jour.*, **15,** 77 (1918).
[2] L. E. Barringer, *Trans. Amer. Ceram. Soc.*, **6,** 86 (1904).
[3] C. W. Parmelee and G. H. Baldwin, *Ibid.*, **15,** 532 (1913).
[4] R. C. Purdy, *Ibid.*, **7,** 105 (1905).
[5] W. L. Howat, *Ibid.*, **18,** 488 (1916).
[6] L. E. Barringer, *Ibid.*, **15,** 544 (1913).
[7] E. C. Stover, *Ibid.*, **18,** 909 (1916).

These articles and discussions give relatively little information which can be applied directly to the use of talc in a vitreous electrical porcelain. It seems desirable that there be more published information in our literature in regard to this important ceramic material.

As a possible source of MgO, talc has several practical advantages over the other sources already mentioned:

1. It is plentiful, and relatively cheap. The cost of MgO from this source is much less than when brought in through magnesite or magnesia.
2. Talc is non-abrasive.
3. It has a small amount of plasticity.[1]
4. It does not give off an objectionable amount of gases in firing.
5. It contains a large percentage of SiO_2. This would tend to reduce the percentage of calcine necessary in the body.

Through taking advantage of these properties of talc, it seems possible to develop a relatively cheap high tension, insulator body, somewhat similar in final composition to the spark plug porcelains of the Bureau of Standards. In general, this was the purpose of the group of experiments described in this article. The maturing temperatures, however, of the bodies to be developed was limited to between cones 9 and 11. This required the retention of part of the feldspar to secure vitrification at this temperature. All of the feldspar was omitted in two of the bodies but this was only for theoretical reasons, not in the hope of obtaining a vitrified body.

Group I

The purpose of this group of bodies was to obtain some idea of the relative fluxing actions of K_2O introduced as feldspar and MgO introduced as talc in the empirical formula of a typical high tension insulator body. (No. 1.)

Body No.	K_2O	MgO	Al_2O_3	SiO_2
1	0.21	....	1.0	4.45
2	0.105	0.105	1.0	4.45
3	....	0.21	1.0	4.45

Batch Weights

Body No.	Eureka feldspar	Vermont talc	Clay base	Penna. flint
1	34.0%	...	48.5%	17.5%
2	16.7	3.2%	55.5	24.6
3	....	6.5	62.4	31.3

From the results of previous analyses, the feldspar was assumed to be approximately 84% feldspar and 16% quartz.

[1] C. W. Parmelee and G. H. Baldwin, *Trans. Amer. Ceram. Soc.*, **15**, 543 (1913); P. Rohland, *Sprechsaal*, **39**, 673–4 (1906).

Method of Making and Testing

The methods used in forming, drying, burning, and testing are similar to those previously reported and need not be repeated here.[1]

RESULTS (CONE $9^3/_4$)

Body No.	Shrinkage in per cent of wet length			Absorption in per cent of dry weight		
	Drying	Burning	Total	Min.	Max.	Aver.
1	3.6	10.2	13.8	0.07	0.11	0.09
2	3.8	11.0	14.8	0.87	3.02	2.24
3	4.6	4.8	9.4	14.86	15.70	15.17

Body No.	Dye test	Modulus of rupture, lbs. per sq. in.		
		Min.	Max.	Average
1	Non-porous	6850	9200	8340
2	Very porous	5220	7000	5940
3	Very porous	3100	3700	3420

	RESISTANCE TO TEMP. CHANGES			IMPACT TEST		
	No. of heats withstood			No. of in. of drop		
	Min.	Max.	Aver.	Min.	Max.	Aver.
1	1	15	6.3	5.5	13.5	10.0
2	7	17	11.0	4.0	5.7	4.9
3	3	6	5.4	3.4	6.7	4.4

	Fracture	Color	Defects
1	Vitreous	White	....
2	Vitreous	White	Blistered—overfired
3	Rough	Very white	Underfired

Conclusions

1. K_2O has a much greater fluxing action at the temperature used than the same number of equivalents of MgO.

2. Since Body No. 2 is overfired, it is evident that the replacement of half the K_2O by MgO gives a greater fluxing action than with an equal number of equivalents of K_2O or MgO alone.

3. The introduction of MgO at the expense of K_2O increases the resistance to temperature changes within limits of composition which cannot be defined on this small amount of data.

4. The data on modulus of rupture and impact are of little value since Body No. 2 is overfired and Body No. 3 is underfired.

Group No. II

In addition to replacing feldspar by talc on a purely theoretical basis as was done in Group I, it was also thought well to replace feldspar by

[1] Robert Twells, Jr. and C. C. Lin, *Jour. Amer. Ceram. Soc.*, **4**, 195 (1921).

talc directly, pound for pound, to determine the relative effect of the two on that basis.

Body No.	Feldspar	Talc	Clay	Flint
1	34.0%	....	48.5%	17.5%
4	....	34.0%	48.5	17.5

RESULTS (CONE $9^3/_4$)

Body No.	Shrinkage in per cent of wet length			Absorption in per cent of dry weight		
	Drying	Burning	Total	Min.	Max.	Average
1	3.6	10.2	13.8	0.07	0.11	0.09
4	4.5	2.0	6.5	21.82	22.40	22.03

Body No.	Dye test	Modulus of rupture, lbs. per sq. in.		
		Min.	Max.	Aver.
1	Non-porous	6850	9200	8340
4	Very porous	1740	2350	2124

	Resistance to Temp. Changes			Impact Test		
	No. of heats withstood			No. of in. of drop		
	Min.	Max.	Aver.	Min.	Max.	Aver.
1	1	15	6.3	5.5	13.5	10.0
4	10	17	13.3	4.5	7.5	5.8

	Fracture	Color
1	Vitreous	White
4	Rough	White

Conclusions

The results of Group II confirm the results of Group I: that at this temperature talc alone is not nearly as powerful a flux as feldspar, and that talc under certain conditions gives a body more resistant to temperature changes.

It is interesting to note that although No. 3 contains less talc, it is nearer vitrification at this temperature than No. 4. The latter, however, is much more resistant to heat changes.

Group III

The most promising field lay between Bodies 1 and 2. Group III was designed to cover this area. It consists of 28 bodies numbered from 5 to 31. Bodies 24 and 28 were not made up. Bodies 25 to 27 and 29 to 31 were made up after the preliminary trials of the other bodies had been seen. To prevent the raw clay content from becoming excessive in the bodies containing only 0.14 and 0.16 equivalents of RO, all but 48.5% of the raw clay was introduced as calcined clay. Only the corner members were blunged up, the rest being made by blending the corner bodies. (See Fig. 1.)

BATCH WEIGHTS OF THE CORNER BODIES

Body No.	Feldspar	Talc	Calcined clay	Clay base	Flint
5	47.2%	...	...	42.6%	10.2%
8	25.8	4.2%	...	51.0	19.0
20	28.8	...	...	50.8	20.4
23	15.8	2.5	...	56.0	25.7
25	21.8	0.8	5.0%	48.5	23.9
27	16.6	2.6	15.5	48.5	16.7
29	19.4	0.6	6.2	48.5	25.2
31	12.5	2.0	8.6	48.5	28.4

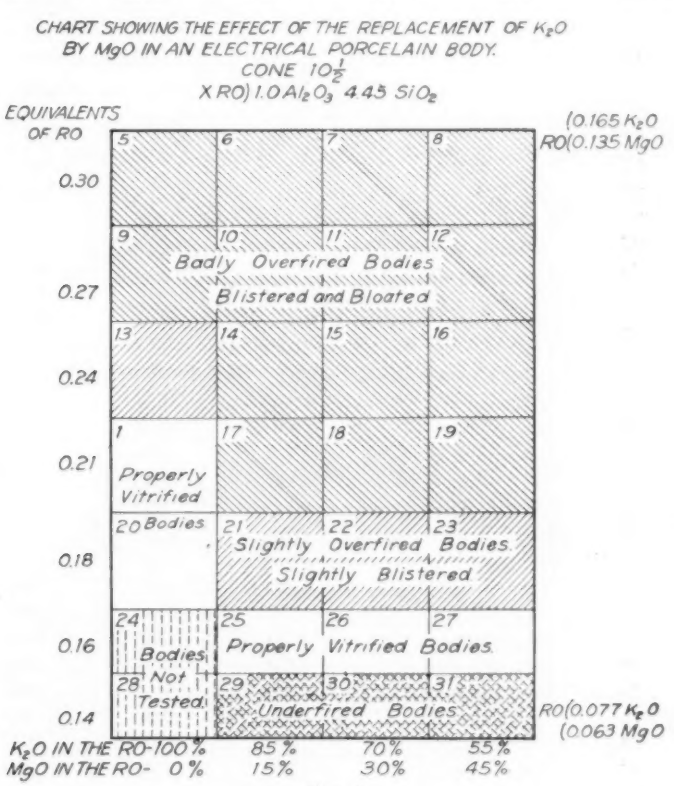


FIG. 1.

RESULTS (CONE $10\frac{1}{2}$)

Body No.	Shrinkage in per cent of wet length: Drying	Burning	Total	Absorption in per cent of dry weight: Average
5	4.0	8.0	12.0	0.69
6	5.5	4.5	10.0	4.85
7	4.5	6.5	11.0	4.59
8	6.0	6.0	12.0	4.85
9	4.5	8.5	13.0	2.89
10	5.0	8.0	13.0	3.55
11	4.5	7.0	11.5	4.75

TABLE (*Continued*)

Body No.	Shrinkage in per cent of wet length: Drying	Burning	Total	Absorption in per cent of dry weight: Average
12	5.5	7.5	13.0	4.81
13	5.0	10.5	15.5	0.15
14	4.5	7.5	12.0	2.82
15	4.5	8.5	13.0	4.67
16	5.5	8.5	14.0	3.17
1	4.0	10.0	14.0	0.15
17	5.5	9.0	14.5	1.82
18	4.5	9.5	14.0	1.30
19	4.5	9.5	14.0	1.06
20	5.0	11.0	16.0	0.14
21	5.0	10.5	15.5	0.17
22	5.5	10.0	15.5	0.29
23	5.5	10.0	15.5	0.65
25	5.0	12.0	17.0	0.09
26	5.1	10.7	15.8	0.15
27	5.5	11.9	17.4	0.08
29	3.6	10.4	14.0	0.63
30	4.9	10.1	15.0	1.33
31	5.9	9.5	15.4	2.78

	Dye test	Modulus of rupture, lbs. per sq. in.: Min.	Max.	Aver.
5	Non-porous	3900	5500	4730
6	Very porous	4250	4670	4510
7	Very porous	3320	5020	4510
8	Very porous	3800	5150	4800
9	Very porous	3960	6900	5430
10	Very porous	4000	5750	4430
11	Very porous	3320	4650	3980
12	Very porous	4050	7790	5840
13	Non-porous	4440	7260	5990
14	Very porous	4410	6850	5630
15	Very porous	3580	5650	4930
16	Very porous	4360	6950	5480
1	Non-porous	7550	8900	8360
17	Very porous	4330	5880	5200
18	Very porous	5180	6400	5800
19	Very porous	5880	7740	6820
20	Non-porous	5040	7200	6125
21	Very porous	5840	11100	8550
22	Very porous	5970	8090	7000
23	Very porous	5640	8900	7040
25	Non-porous	...	...	6975
26	Non-porous	...	...	8360
27	Non-porous	...	...	9400
29	Very porous	...	...	8080
30	Very porous	...	...	7800
31	Very porous	...	...	6200

The heat resistance test was not made because the furnace normally used was needed in production. The impact test was made, but the results are omitted since they merely confirm the results of the modulus of rupture test without being as accurate.

Conclusions (Cone $10^1/_2$)

1. A very small amount of talc greatly decreases the amount of feldspar necessary for vitrification.

2. Additional amounts of talc have a much less noticeable effect than the first small addition.

3. Bodies containing talc have good strength when properly vitrified. The results of the tests on the properly vitrified bodies indicate that within limits the transverse strength tends to increase as MgO is substituted for K_2O.

4. About 0.16 equivalents of RO are needed for vitrification at this temperature when small percentages of talc are used. This corresponds to about 15% to 22.5% of feldspar depending on the amount of talc used.

The effect of the addition of talc is of course very similar to what is expected when any mineral containing alkaline earths is used. The above series, however, helps to throw some light on the best way to proportion the various body constituents.

Group IV

The next step consisted in applying the information learned towards a more practical body than any tried thus far. Group 4 was part of a

BATCH WEIGHTS

Body No.	Feldspar	Talc	Whiting	Clay base	Flint
1	34.0%	...	...	48.5%	17.5%
32	22.5	0.75%	....	48.5	28.25
33	16.9	...	3.1%	48.5	34.0

The materials are the same as those previously used.

RESULTS (CONE 9)

Body No.	Shrinkage in per cent of wet length			Absorption in per cent of dry weight
	Drying	Burning	Total	Average
1	3.3	12.1	15.4	0.03
32	5.0	10.0	15.0	0.01
33	5.1	10.3	15.4	0.05

Body No.	Dye test	Modulus of rupture, lbs. per sq. in. Average
1	Non-porous	7700
32	Non-porous	7850
33	Non-porous	7550

series using various fluxes. For this reason but one body of this type was tried. It is similar to Body No. 25 with the calcined clay replaced by flint. For comparison the data is also given on an electrical porcelain similar in type to Body No. 27, but containing whiting for talc, and flint for calcined clay.

The appearance of all three bodies is very similar. All are straight white in color, and properly vitrified.

No very definite conclusions can be drawn from the trial of one or two bodies. The results indicate that in the development of transverse strength, the type of flux or the relative percentages of fluxes are not as important as the proper vitrification of the bodies. The chief point of interest is that in Body No. 32, 0.75% of talc has allowed the feldspar to be cut from 34% to 22.5% without decreasing the vitrification or strength.

Due to other experiments no dielectric tests were made on the latter part of these bodies. It is doubtful whether, in a body of the type of No. 32, the hot dielectric strength would be greatly increased. If this is true, the next logical step towards the development of the desired superior high tension insulator porcelain, is to try vitreous bodies, fluxed entirely or almost entirely by MgO introduced through talc. To do this it seems necessary to increase the temperature at which the body is to be fired. Higher temperatures, of course, mean added difficulty and expense, but tunnel kilns and better refractories have made these temperatures more practical commercially than they have hitherto been.

HIGHLAND PARK, MICH.

REFRACTORY CLAYS OF ILLINOIS[1]

By C. W. Parmelee[2]

ABSTRACT

A brief discussion of the geological occurrence of the fire-clay beds in Illinois and the results of testing samples which are typical of various areas.

Introduction.—An examination of the geological map of the state of Illinois will show that almost all of it is covered by a heavy mantle of glacial material. Buried under this lie the coal measures, excepting in the northernmost counties and the extreme southern tip. Along the western side of the state beginning at the extreme south and roughly paralleling the course of the Mississippi River and in the north central part of the state we find exposures of these Pennsylvanian beds which afford opportunities for mining the clays and shales which lie interbedded in these deposits. Across the southern tip of the State we find an extension of the Embayment area. In Union County which lies a little north of this tip of the Embayment area there is an isolated deposit of much importance. Besides these areas we have the occurrence of clays and shales with coal beds which are at a considerable depth and are accessible only as the coal is mined. This, in brief, is the general outline of the occurrence of the refractory clays in Illinois. Considering them more in detail we will begin with those found in the Embayment area in the extreme southern portion.

Embayment Area.—At a period subsequent to the formation of the Coal Measures, the Gulf of Mexico extended northward as a bay of comparatively narrow width considering its great length. This bay covered the western portion of Tennessee and Kentucky and the eastern part of Arkansas. The deposits of clays and sands which were laid down in that area at that time are known to belong to the Cretaceous and Tertiary age and among them we find the very important deposits of bond clays in Mississippi and Arkansas and the ball clays, etc., of Tennessee and Kentucky. The extension of this embayment area is found in the counties of Massac, Pulaski and Alexander in Illinois. Undoubtedly, it extended somewhat farther north since remnants are found as terraces and thin beds 150 feet and more above the present valley level and small outliers have been reported at a much higher elevation which may indicate a thickness of the original deposit far greater than is apparent from the portion still remaining *in situ*.

Only the uppermost or latest of the three lower embayment formations of the Cretaceous extends into Illinois. This is correlated with the Ripley formation of Tennessee and Kentucky. It occurs in the form of a curved

[1] The author is indebted to Mr. F. W. DeWolf, Chief of the Illinois Geological Survey for permission to publish this résumé; also acknowledgment is made of the use of geological data as interpreted by C. S. Schroyer, formerly of the Survey.

[2] Read before Refractories Division, St. Louis Meeting, Feb. 28, 1922.

belt varying in width from 5 to 15 miles. The deposit consists of sands varying in color: pink, light yellow and brown. The clays are a gray, or slate color and are from 3 to 15 feet thick.

Clays from this formation have been used for many years in the manufacture of stoneware. The one deposit which is being worked is rather siliceous. A sample which was obtained by boring gave the following test:

	No. 47	No. 38
Water of plasticity	25%	38.6%
Strength of clay only in terms of modulus of rupture, pounds per sq. in	365	164
Drying shrinkage	6.8%	7.8%
Burning test		
Porosity at cone 9	7.6	14.
Color	gray	cream
Shrinkage	4.4	6
Fusion test—deforms at cone	27	30

Midway Formation.—These are the oldest beds of the Tertiary age. Their exposures along the Ohio river are in the form of a high bluff extending only a short distance. These beds are of interest because of the occurrence of fuller's earth. No refractory clays are found.

Union County.—In the northwestern part of Union County there is a limited area which is of especial interest to the ceramist as well as the geologist. In a district comprising about five square miles is found a deposit of clays of unusual character. The geology of the district includes Devonian, and Mississippian formations and not far to the north are found the Pennsylvanian formations. The region is intersected by a fault which traverses the district in a northwestern-southeasterly direction. This faulting has evidently formed basins, which apparently served at one time for the accumulation of deep beds of clay. The source of these clays has not been determined satisfactorily. It has been suggested that they may have originated through the decomposition of readily soluble Mississippian limestones of the district in the same manner as the Lutesville, Mo. kaolin deposits very evidently were formed.

On the other hand, a similarity is noted in the character of these clays as compared with certain deposits to the south and east, as well as in Kentucky, as though the original deposit may have been very extensive.

There are five kinds of clay obtained in this district: a bluish white, a white, a pink, a mottled and a brownish clay.

The clay deposits seem to have been formed in the following order. First, a white sand, then a bluish white clay. Lignite is found mixed with this clay in some deposits forming a brownish clay of very good grade since the color is due solely to organic matter and is not harmful. Next in order was the deposition of the white clay which was followed by the pink and

mottled clays. The mottling as seen on a freshly cut face is very brilliant in coloring and seems to be due to the leaching of iron salts from the gravel overburden. In fact one of the curious features of the whole deposit is the shell of hematite and limonite which is found in some places at the contact of the sands and gravels with the clay. Where fissures have opened in the clay beds due to movement of the strata, thick layers of hematite may be seen following the course of percolating waters. Results of test:

	No. F	No. K₂
Water of plasticity	37.4%	41.4%
Strength of clay only, modulus of rupture in pounds per sq. in.	142.5	195.6
Bonding strength	259	202
Screen test—total residues on all screens including 200 M...	5.7%	...
Drying shrinkage—in terms of dry length	5.6	11
Burning tests		
Porosity at cone 9	3.2	7
Shrinkage	11.5	14
Color	gray	gray
Fusion test—deforms at cone 33 and higher		

The overburden is gravel varying in thickness from a foot or two to fifteen feet. It consists of loess and gravel. The clays vary greatly in thickness in a limited area. On one property a shaft was sunk to a depth of 93 feet in the deposit. The whole area is not continuously underlain by clay but the district is intersected by limestone ledges due to the faulting.

The clay is dug by means of open pits or by shaft and tunnels. In the former case, steam shovels are used to remove the overburden and also to dig the clay.

The type clay from this district has the following characteristics. High plasticity which is somewhat sticky. High drying shrinkage with warping tendency. Medium to low bonding strength. It burns to a white to cream color and bluestones at the higher temperatures. A minimum porosity is reached at about cone 5 and they do not overburn at cone 14. The burning shrinkage is high and the clay is intersected by an extensive series of internal cracks; also it shows a marked tendency to warp. These clays have found use for bonding in the manufacture of crucibles, abrasive wheels and miscellaneous refractories.

The third clay zone extends along the western part of the state from St. Clair County northward through Madison, Calhoun, Greene, Pike, Scott, Adams, Brown, Schuyler, McDonough, Fulton, Warren, Rock Island and Mercer Counties. An extension of this zone is found in the north central part of the state in LaSalle and Grundy Counties. Stratigraphically we find the base of the Pennsylvanian series exposed in the counties

mentioned and from this geological formation we obtain our refractory clays.

The Cheltenham formation underlying St. Louis which furnishes such excellent fire clays extends into Illinois. There are some doubts as to the correlation of the clays with this horizon in the more northern counties. David White[1] expressed this opinion a few years ago, after a study of the Coal Measures, that the clays worked at Utica belong to the Cheltenham horizon.

Later Cady[2] studied the La Salle and Hennepin quadrangles and came to the conclusion that the upper clays below No. 2 coal are probably Cheltenham.

Where the Cheltenham clays have been definitely recognized in Illinois, material may be obtained by careful selection which is said to be equal to the best of the St. Louis district.

Obviously it is impossible to enter into a detailed discussion of the clays of this zone. That data will shortly appear in a bulletin of the Illinois Geological Survey. A brief summary will be given for the more important centers of production.

Greene County.—For many years clays have been dug in the vicinity of White Hall and Drake. Most of the tonnage has been used locally for stoneware. Some clay was formerly shipped. In general, the best clays have the characteristics usually associated with stoneware clays; namely, they are plastic and have a good strength, burn to a porosity of 5% or less at cone 9 or lower, and when burned have a cream color. The fusion point is variable, ordinarily is about cone 27. Results of test:

	No. 49	No. 52
Water of plasticity	24.3%	23%
Modulus of rupture—clay only, pounds per sq. inch	369	380
Modulus of rupture—bonding test	190	244
Slaking test	23 min.	10 min.
Screen residues—total incl. 200 m	3%	14%
Linear drying shrinkage—per cent dry length	5	5
Burning tests		
Porosity at cone 9	9.6	2.0
Color	cream	gray
Burning shrinkage at cone 9	5.6	6.
Overburned at cone	15.	Not overburned
Fusion test	cone 30	26

These clays are bedded. They are covered by an overburden of 10 to 30 feet of loam, gravel, and shale. Mining is done in an open pit.

[1] *Ill. Geol. Surv. Bull.*, **14**, 294 (1909).

[2] Cady, "Hennepin and LaSalle Quadrangles," *Ill. Geol. Surv. Bull.*, **37**, 53 (1919).

Scott County.—Cheltenham clay is exposed in the bank of Mauvias Terre Creek, one-half mile west of Exeter. It tests as follows:

	No. 65
Water of plasticity	22%
Modulus of rupture—clay only, in pounds per sq. in.	240
Sieve residues on all including 200 mesh	7%
Drying shrinkage in terms of dry length	5
Burning conduct	
Porosity at cone 9	17
Shrinkage at cone 9	4
Color	light tan
Porosity at cone 15	7
Fusion test	cone 30

Fire brick have been made at Alsey from clay taken from between a 5-foot stratum of limestone and 3-foot bed of coal. Production in 1918 reached 20,000 brick a day. According to a test of the U. S. Bureau of Standards these brick had a softening point of cone $31\frac{1}{2}$.

A sample taken from the old stock pile of the plant showed the clay to have the following test:

	Samples No. 71
Water of plasticity	22%
Modulus of rupture—clay only, pounds per sq. in.	328
Linear drying shrinkage in terms of dry length	6%
Burning conduct	
Porosity at cone 9	10
Color at cone 9	Cream
Linear shrinkage	6
Fusion test	cone 28

McDonough County.—This is one of the important clay producing centers which is rivalled only by Greene County. Clay is dug extensively near Colchester and Macomb.

The following tests represent the best of the results obtained on two samples:

	Samples No. 78	No. 75
Water of plasticity	19%	21%
Modulus of rupture in lbs. per sq. in., clay only	325	295
Modulus of rupture—bonding test	209	...
Sieve residues—all including 200 mesh	4%	...
Drying shrinkage—in terms of dry length	4	4.7%
Burning conduct		
Porosity at cone 9	15	6.8
Shrinkage at cone 9	4	11.
Color at cone 9	cream	...
Porosity at cone 15	6.5	4.0
Fusion test	cone 29	above cone 30

Rock Island County.—Lines[1] reports that fire brick were made at Carbon Cliff. When visited by a representative of the Survey in 1918, the manufacture of brick had been discontinued, and the face of the old pit was badly slumped. This is regarded as of the Cheltenham horizon. Samples of clay gathered elsewhere in the county proved to be too fusible to be considered as refractory clays.

LaSalle County.—Brief mention only can be made of various producers.

Utica Fire Brick and Clay Co.—The pits are situated two miles south of Utica above the river bluffs. The clay is mined, loaded into train and hauled to a tipple where it is dumped into cars at the river level, transferred across the Illinois River by barge and hauled to the plant at Utica. Besides the production of about 20,000 fire brick per day, crude and ground fire clay are shipped..

A test of a sample from the pit gave the following results:

	Sample No. 87
Water of plasticity	25.6%
Strength of clay only—modulus of rupture per sq. in	497
Bonding test—modulus of rupture in lbs. per sq. in	290
Screen residues—total on all, including 200 mesh	2%
Drying shrinkage—in terms of dry length	9.3
Burning test	
Porosity at cone 9	8.2
Shrinkage at cone 9	5.1
Color	Cream
Porosity at cone 14	5%
Fusion test	cone 28

Pits of M. J. Gorman and Co., about $1^1/_2$ miles from Utica.

	Sample No. 100
Water of plasticity	24.6%
Strength of clay only—modulus of rupture per sq. in	475
Bonding strength—modulus of rupture	222
Screen residues—total on all, including 200 mesh	29.0%
Drying shrinkage—in terms of wet length	7.3
Burning test	
Porosity at cone 9	6%
Shrinkage at cone 9	5.5
Fusion test	cone 31

The Illinois Clay Products Co. at Deer Park.—A 13-foot stratum of clay lies below a $3^1/_2$ foot seam of coal. A sample taken from this clay tested as follows:

[1] *Ill. Geo. Survey Bull.*, **30**, 72 (1917).

Water of plasticity	25%
Strength of clay only—modulus of rupture, pounds per sq. in	504
Bonding test—modulus of rupture per sq. in	302
Drying shrinkage in terms of dry length	7.8%
Burning test	
Porosity at cone 8	2.2
Shrinkage at cone 8	5.5
Porosity at cone 15	4.6
Fusion test—deforms at cone	29

Lowell Stoneware Company at Lowell.—Fire clay is found below $3\frac{1}{2}$ feet of coal in the bluff of the Big Vermillion River. The thickness of the bed varies from 12 to 25 feet and it is said to underlie about 290 acres. A sample taken from the deposit tested as follows:

	No. 90
Water of plasticity	20.80%
Strength of clay only—modulus of rupture lbs. per sq. in	420
Bonding strength	290
Drying shrinkage in terms of dry length	6.8%
Burning test	
Porosity at cone 9	9.5
Shrinkage at cone 9	5.7
Color	dark cream
Porosity at cone 15	2.0
Fusion test	cone 30½

National Fire Proofing Co.—At Twin Bluffs, the National Fire Proofing Company is taking out clay from an open cut. A sample from there tested as follows:

	No. 94
Water of plasticity	16.9%
Strength of clay only—modulus of rupture in lbs. per sq. in	140
Drying shrinkage in terms of dry length	4%
Burning test	
Porosity at cone 9	22
Shrinkage at cone 9	2
Porosity at cone 15	11
Fusion test	cone 31

The Herrick Clay Manufacturing Company situated about a mile east of the above property is mining from the same horizon. A test of the clay shows it to have a strength expressed in modulus of rupture as 157 pounds per square inch and a fusion test of cone 27.

The Chicago Retort and Fire Brick Company.—The pits of this company are about 2 miles east of Ottawa. They are manufacturing fire brick using their own clay and also clay from Missouri.

A sample taken from a 4-to-8 foot stratum at the bottom of the pit tested as follows:

	No. 101
Water of plasticity	20%
Strength in terms of modulus of rupture, pounds per sq. in. max	532
Bonding strength—max	296
Drying shrinkage in terms of dry length	7%
Burning tests	
Porosity at cone 9	13
Shrinkage	4.4
Color	cream
Porosity at cone 15	13%
Fusion test	cone 29

One-half mile south of Dayton the Dayton Clay Works mines a fire clay which tests as follows:

	Sample No. 99
Water of plasticity	15.9%
Strength of the clay alone in terms of the modulus of rupture in lbs. per sq. in	215
Bonding strength—modulus of rupture	107
Drying shrinkage in terms of dry length	4.9%
Burning conduct	
Porosity at cone 9	19
Fusion test	cone 30

Grundy County.—A deposit of clay of exceptional interest is found in what was formerly the bed of Goose Lake. It is a flint clay in character and the only deposit of this kind which has thus far been located in Illinois. The local geological conditions suggest that this basin was separated from the main body of the Coal Measures Sea to the south and that this deposit represents an accumulation in solution basins of the Crystalline Richmond limestone which outcrops to the north. Borings to the depth of 30 feet have been made without reaching the bottom of the clay. The flint or semi-flint clay is covered by a light overburden. A test of this clay shows the following results:

Water of plasticity	18
Drying shrinkage in terms of dry length	3.6%
Bonding test—modulus of rupture in pounds per sq. in.	59.6
Burning test	
Porosity at cone 9	17%
Shrinkage	5
Fusion test about cone	28

CERAMICS DEPARTMENT
UNIVERSITY OF ILLINOIS
URBANA, ILL.

THE PASSING OF KING METHANE[1]

By S. R. Scholes

Forty years ago there was always great disappointment when the hopeful driller for petroleum struck a pocket of natural gas. He might be obliged to wait for several days while the gas roared into the air, before tools could be removed, or the well probed further for oil. Sometimes a "gasser" caught fire, and the great torch, consuming millions of cubic feet of gas daily, lighted the whole countryside.

Twenty years later, natural gas had become the standard glass-house fuel, and the so-called "gas-belt," comprising parts of western Pennsylvania, West Virginia, Ohio, and Indiana, became also the glass belt, and here the most of the factories were operated.

Today the price of natural gas, except in favored localities, is almost prohibitive for the manufacturer. Moreover, for several years past, the gas has been low in supply in cold weather. This is chiefly because of the increased domestic demand, for the gas-belt household must still have its wasteful grates and sometimes heating furnaces fired with gas. And in extremely cold weather, the condensation of moisture as the warm gas issues from the wells into the cold pipes sometimes chokes off a large part of the supply at the source.

Thus, in less than four decades the most ideal of all industrial fuels has run its course from a nuisance to a luxury. Many of us can recall the words of our first text-book on organic chemistry: "Methane.....is found issuing from the ground in some localities." Probably more of it has issued from the ground into the atmosphere than has ever issued from pipes since it became industrially prominent. It has not yet ceased to flow; far from it, but new gas wells are more and more speculative ventures, with production barely able to keep up with the warm weather demand.

Of all the materials stored in the bosom of Mother Earth for her human sons to find and use, none other seems so ideally adapted to the caloric needs of man as natural gas. The combustion of one cubic foot of it yields a thousand British thermal units, which is nearly double the calorific value of coal gas. It is free from sulphur. It requires some ten times its own volume of air for its combustion, and the leisurely travel of the flame through the mixture makes the flame long enough for any furnace. It is clean and dustless and almost odorless. There is scarcely a place where fuel is required where natural gas does not excel. For glass furnaces it is ideal—no other word describes it.

But all of these encomiums might almost be written in the past tense, so far as the glass manufacturer is concerned. New wells are being brought

[1] Presented at the St. Louis Meeting, Feb. 28, 1922.

in, to be sure, but they do not take the place of old ones that are breathing their last. A year or two ago, some tremendous gas wells were brought in near McKeesport, Pa. As a result of the first strike, a fever of drilling, accompanied by a worse disease of speculation and blue-sky financing, made McKeesport a familiar name on many a beautiful stock certificate. The town was bored so full of holes that it might well have been called "Sieveport." It is all over now, and the gas obtained has cost at least $1.25 per thousand. West Virginia is still producing immense quantities, but her citizens realize the fact that the gas will soon be gone. Forgetting that the control of interstate commerce is purely a Federal function, they tried to prevent by law the piping of gas out of the State. If this had been a constitutional procedure, the glass factories of adjoining states would have been brought a little earlier face to face with the problem of finding a successor to King Methane. Oklahoma and other western states are developing gas fields, but they are too far from the centers of population to be industrially important.

During the gradual shortening of the gas supply as winter followed winter, glass factories, to avoid periodical shut-downs, have been obliged to be prepared to use alternative fuels. Chief among these is producer gas, the stand-by before natural gas was known. Fortunately for industry, the inventors of gas-producers have so spent their time during the years when sooty, tarry, poisonous, evil-odored producer gas was kept from the field by its sweet-breathed cousin, that the producer to which the glass manufacturer turns today is an entirely different piece of apparatus from that of a generation ago. Mechanical poking, pressure regulation, pyrometric temperature control, and improved design and construction have made the generation of producer gas from soft coal far more of an exact process. The furnace teaser can count on gas under steady pressure, with a heat value approximating at all times 140 B.t.u. per cubic foot.

It is a difficult matter to bring up a cold furnace with this gas, but when once the regenerator checkers are heated, the maintenance of constant high temperature is only a matter of care. The one outstanding drawback is the necessity of burning out once a week the soot and tar accumulated in the mains. And apparently the soot and tar are actually desirable, to give the flame of producer gas a luminous character, so that it will radiate more heat upon the glass in tanks, or upon the pots in furnaces than would the non-luminous flame of the clean gas, whose principal fuel component is carbon monoxide.

It is within the range of possibilities that coal gas from by-product coke ovens may be made for glass furnaces. Perhaps such a development must wait until the immense tonnage of coke that would be thereby produced can find a market. Or perhaps a combination of coal- and water-gas, such as many city gas-works produce, may be made at a cost where its

advantages of cleanliness and high heat value enable it to compete with that dirty but inexpensive fog, producer gas.

Fuel oil has reached an importance such that it deserves more than honorable mention as a glass-house fuel. For the benefit of those who are not acquainted with this fuel, it should be said that most fuel oils are black, heavy, and viscous. They require to be pumped warm, and are usually fed to the burners at temperatures of 120°F or higher. Several types of burners are in use, and the spraying of the oil into the furnace is accomplished in various ways. Large and small nozzle orifices, low and high pressures of oil and the air that atomizes it, are all more or less successful, and all require the same careful attention. The choice of an oil-burning system may be said to be a matter of individual preference, depending somewhat on the furnace to be heated.

The oil flame is very hot and incandescent, and therefore well adapted to glass melting. It is a trifle too short and intense, however, and local over-heating of refractories is an evil attending its use.

In the matter of cost, oil fluctuates rapidly and widely, according to the demand and supply. It also has a seasonal swing in price, being more expensive in cold weather. Therefore it requires a careful purchasing agent to keep a factory supplied with oil at an advantageous price.

Having discussed the sources of heat, let us turn for a little to the application of the dearly-bought B.t.u.'s. One ton of good bituminous coal will furnish 28,000,000 B.t.u., about 30% of which heat is lost in the conversion to producer gas, leaving 19,600,000 B.t.u. delivered to the furnace. In a good tank, where the glass need not be too clear, this coal will melt 3,000 lbs. of glass, where 1,000 lbs. is fed as cullet, 2,000 lbs. as raw material. The following figures, which are typical rather than exact, may be derived:

Heat consumed in decomposing soda		745,000 B.t.u.
Heat produced by formation of sod. sil.	352,000	
Heat produced by formation of calcium sil.	43,000	
		395,000 B.t.u.
Net heat consumed by chemical reactions		350,000 B.t.u.
3000 × .2 (sp. ht.) × 2500 = Heat absorbed by glass at maximum temperature		1,500,000 B.t.u.
Total heat consumed by melting glass		1,850,000 B.t.u.

$\frac{1,850,000}{19,6000,000}$ gives .094, or 9.4% efficiency.

Of the remaining heat units produced from the combustion of a ton of coal, 4,200,000, or 21.4%, go up the stack, assuming that the stack gases are at 600°F. The balance of something over 69% is lost by radiation.

While the heat balance worked out above is on the basis of coal burned, the same results are found when natural gas or oil is the fuel, since these three fuels replace one another in proportion to their calorific power.

The item of 69% lost by radiation is a conservative figure, since few tank furnaces turn out as much as 3,000 lbs. of glass per ton of coal burned. And in pot furnaces this output drops below 2,000 lbs. and is sometimes as low as 1,000 lbs. The question arises how this enormous loss may be cut down, or to put it positively, how the meager efficiency of the glass furnace can be raised. The obvious answer is, apparently, by heat insulation. The walls and crown of the furnace are nowhere more than one foot thick. Why not cover these, and also the walls of regenerator chambers and uptakes, and cut down this rapid flow of heat? The answer is that tank-blocks, crown and checker bricks, are now right at the limit of their endurance, and it seems essential to their preservation to keep them cool on the outside, and allow the heat to flow through them. Otherwise they would respectively dissolve in the glass, or spawl off in fragments or slag down, thus causing more loss than the saving of fuel could offset.

While these remarks set forth the present status of glass-house refractories, they do not mean that we are at the end of progress in this direction. The time has come when the makers of refractories must develop something that will stand up for its usual life in a glass furnace, covered with insulation. In the heyday of King Methane's reign, when natural gas sold for six cents a thousand feet (with or without a factory site thrown in) nobody minded the waste of gas. But now, with gas at forty-five cents and up, and little to be had, and coal at six dollars, and oil at whatever the traffic will bear, something real must be done to economize fuel.

Another direction in which effort might well be expended toward the saving of fuel is in the design of glass furnaces and tanks. When a civil engineer sets out to build a bridge, he has at his command accurate data on stresses, strength of materials, and the like. And, barring the occasional slipping of a decimal point, his bridge will be safe for its traffic, without waste of steel. But are there any like data for the builder of a glass tank? Does anyone really know how high the crown should be, or what is the best width of tank and length of melting end for a given tonnage, or what the shape and size of ports and checkers should be, for the most efficient operation? Apparently not, for there are a great variety of tanks, different in design according to the whims of their builders, with no demonstrated standards anywhere. This should not be so, for there are undoubtedly definite principles making for economy of fuel in glass furnaces, and it is time they were established and made known.

With true American prodigality, we have already blown into the air or burned almost all of our treasure of natural gas. And now, with true American inventiveness, we must improve furnace and refractories so as to get far better efficiencies from the burning of King Methane's successors.

FEDERAL GLASS CO.
COLUMBUS, OHIO

Discussion

J. C. HOSTETTER:—The discussion of this paper seems to me to take in everything connected with glass melting, and while it is unfortunate that Mr. Scholes is not here to reply to your comments, I hope we may have a generous discussion of the paper among ourselves, even in his absence.

It may be of interest to you to know of the successful installation of concrete oil storage tanks at the present time. We installed one recently in Corning, with a capacity of about seventy-five thousand gallons, and it is working out successfully. It is "fool-proof," in the sense that if any leakage should take place, it is shown immediately by the water seal on the outside; that is, an indication is given immediately. The tank is divided into two compartments each equipped with sumps for collecting water and debris introduced with the oil. A steam heating arrangement maintains the oil at a constant temperature throughout the year or at least, above a certain minimum temperature, and it is working out successfully. This storage capacity cost us about $14,400 at the peak of prices including excavation, so that compared with steel tanks the cost is not excessive.

MR. H. L. DIXON:—You know, in all the years I have been engaged in the practical business of building and developing furnaces for making glass, I have grown more and more every year to realize my lack of technical education in these matters. I have grown more and more every year, as I attend meetings of this character, to appreciate the wonderful work that the technical boys are doing in the development, in the explanation, in the disclosure of all of the great forces that we have been using for years and years, in the use of fuel in the making of glass. Of course, I don't know anything about glass except in a casual way.

Now, there are one or two statements that Mr. Scholes makes that I take exception to. As a result of experiments, trials and demonstrations we have derived certain fundamental principles which we use in designing furnaces that don't exactly demonstrate properly. There are certain fundamental rules that have not been determined by any scientific method or by the schools, or any scientists, or anybody, but which have been determined absolutely by practice. The area, for instance, of a tank for melting a certain amount of glass has been absolutely determined. There is, of course, a difference of opinion, different builders and different methods; but there are very well established fundamental rules nevertheless. For instance, if a man wants to build a tank to make fifty tons of glass in twenty-four hours, there are well-fixed rules for establishing what size that tank should be.

I agree with Mr. Scholes that one of the most serious problems that furnace builders have to contend with is the matter of refractories. The materials from which the furnace must be built ought to be the subject

of very intensive study of just such organizations as this. The ordinary furnace builder like myself doesn't know very much about the science of fuels and of refractories except as gained through constant use and experience. Of course, we read all these papers and try to digest them, and if we run across certain things we do not understand, we go into our libraries and dig out our text books and try to understand them, but when we get through we know very little more than when we began.

Now, the fact is this: What we can do, and what we can promise a customer, for instance, is based absolutely upon what we have experienced and gone through in our day and time. I will say frankly and I believe every man within the sound of my voice will agree with me that we learn a hundred times more through our mistakes than we do through our success. If we happen to build a furnace for somebody, and it doesn't work right we have to pay for it; and we do not forget that.

Now, is it not a reproach to those who were in the glass business during the last century that two articles they thought they had to have were by mere accident found to be unnecessary? There are a large number of men today using the main ingredients, silica, soda and lime, and a little decolorizer, and nothing else. The man that uses "dope" in his glass doesn't know the glass business. The best glass that is made today is made without "dope."

Now, I want to say, Mr. Chairman, as a man not possessing the technical knowledge that you boys do, I preach all these so much, that I can not tell you what I think of it—I cannot express my appreciation of the wonderful things that have been brought about by the study and experience of the boys that are really in the glass factories, and of what they are doing: but here is one thing I want to say. It is not a question in your study of what you can use in making glass: the intensive study you should make is as to what you can do without and abolish.

MR. A. E. WILLIAMS:—I would like to ask Dixon if he can give us the limits of insulations that can be put on the present refractories, if any can be put on at all.

MR. DIXON:—I am glad you asked that question, for we have made absolute determinations. We can insulate the parts which are subject to moderate temperatures, but when we come to the crown of the furnace—in other words, the melting chamber—if that is covered with an insulating material it only lasts a short time. It has become well known that the insulation of that part of the furnace is absolutely impossible, if you want to maintain the furnace for any length of time.

The dirt and dust and everything in a furnace accumulates on the crown, it prevents radiation causing the arch to burn through and give way in a very much shorter time than it would if it is kept perfectly clean.

MR. HESS:—The industrial application of fuel gases, I think, is rapidly

assuming an entirely new aspect. It is not only a question of producing a glass or melting glass in a definite time, but the matter of the quality of the gas is a very important point to be considered, especially since we have gone into the use of automatic machinery. Undoubtedly within the next few years the development of the gas industry will be so great that in most of the gas plants, especially those located in the larger cities, it will be possible to secure a variety of gases, so we may either make our own producer gases, or we may secure gas from plants that will be located in the industrial district and which will distribute cheap fuel through high pressure lines for specific purposes. I happen to know of experiments which are now being made with blue-water gas in the melting of glass. I have tried such experiments myself, but they were in a furnace built for the ordinary producer gas and the results were not good; but, in other cases I have seen some very good results. For certain work a type of very clean gas is needed.

Some of the larger gas companies are doing a great deal of work with reference to manufacturing industrial gas locally and distributing it in the immediate vicinity to the factories. The glass factory will be able to utilize such gas for it will be available at prices which will be favorable to the specific purposes for which they are used. I think that the fuel problem should be given much attention because for certain purposes we can only use the more expensive, while for other purposes we can use a cheap fuel gas.

MR. YUNG:—It seems to me that there are a few points in the construction of tank furnaces that ought to be brought up, which have a tremendous effect upon fuel consumption. There are a good many manufacturers, who, as Mr. Dixon has said, will come to him and tell him they want a furnace of such and such a tonnage, and they want one, two or three machines to the furnace. It makes a difference whether you put one, two or three machines on a furnace in your fuel consumption per ton of glass melted. There is a point at which you will get a minimum loss through radiation per machine. If you put fifty machines around the tank, it would mean a large working diameter for your tank, and that large diameter would represent a large area of radiating surface per machine and consequently per pound of glass melted. Perhaps one machine to the tank would be going the other way. I think this is a point that the furnace builders and manufacturers should take up in the designing of furnaces—the determination of the most economical number of any particular machine to operate on a tank.

Now another subject which today is undetermined; we know that the first four or five or six inches of the tank block do not stand up very long; nevertheless, it has some value in the tank. It lasts a certain length of time; perhaps it is only two or three or four months. That being the case, just where is the balance between the cost of this extra six inches in the tank block, the pollution of the glass and the benefit derived?

Another thing that seems to me might be of help in economizing; you can lay out a tank with a radiation of fourteen to sixteen square feet to the ton. You might run the temperature of this tank up and be able to melt one and a half times as much glass. Unquestionably, the life of your tank will be shortened by increasing your temperature, but where is the balance on the cost sheet between spending that additional fuel to obtain higher temperatures, melting your flux blocks out and the increased production?

J. C. HOSTETTER:—The points brought out by Mr. Yung are very important. Going back to Mr. Dixon's reference to the technical boys Mr. Yung's statement brings in the necessary condition that if the technical man is to give us much of value, he must introduce the dollar sign into his calculations.

Referring to the thickness of tank blocks, if it is the last four or five inches of the block that counts, then put in the extra eight to make it a twelve-inch block? It is a problem, and we must get the solution to it some of these days. The life of a tank under comparable conditions is determined by the temperature of operation. I think that is unquestionably true. Therefore, to compare tank performance we should have not only the volume of glass passing through per unit time but the temperature at which it was operated, and also we should consider the area of the melting end; and perhaps the entire area of the tank. I think it is only by taking all these factors, and several others into consideration that we will be able to compare the service of different tanks and the performance of refractories.

MR. D. W. ROSS:—In some quarters the question of the thickness of the block is treated more or less as a joke. In the light of the fact that each day's extra production means a thousand or more dollars worth of ware, one manufacturer has jokingly said, that it requires only two days increase in the life of a tank to pay for the additional amount of block eaten away and also that this extra portion of block makes good glass.

MR. HOSTETTER:—There is a little bit of evidence perhaps contradicting Mr. Dixon's statement that "dope" isn't necessary in the glass.

MR. DIXON:—One thing above everything else I don't want to be misunderstood: Mr. Yung has sketched a tank for making bulbs, which all of you know is a recent development. There was a time when nobody believed that bulbs could be made from anything but lead glass. I remember that for years nobody else could make a bulb that anybody would buy unless it was made in Corning. They had a strike and the Liberty people started in competition, and that is when they first found out somebody else could make them besides the Corning Glass Works.

For years they made the bulb of lead glass from certain tanks, and they found out afterward that it was possible to make a bulb for incandescent

lamps, with the proper expansion and everything of that sort, differently, and that tank he sketched out there was the result. You can easily realize it is absolutely reversed from the ordinary method of building tanks. All the methods we had had in tank building were directed to increase production. Now, all of you know we succeeded in accomplishing that. It is not a fair proposition for Mr. Yung to use his bulb tank as a general tank proposition. It is an exceptional proposition: absolutely so.

MR. WILLIAMS:—The closing paragraphs of Mr. Scholes's paper should give members of the glass division food for thought. The need of accurate data and comparative data of the fuel and furnace problems of the glass industry is becoming ever more evident as one notes the interest any article on this subject arouses.

Those who were present at the St. Louis Meeting will remember some of the interesting discussion following Mr. Scholes's paper and the many facts of interest mentioned. What a profitable meeting it would be if the great variety of opinions regarding the construction of any single type of furnace could be mentioned and compared. Could not the next Annual Meeting be made a time for special discussion of this important subject with the object of presenting comparative data on furnace construction and production.

Such a program would bring manufacturers, ceramic chemists, and engineers together with a very profitable advantage to all concerned. The Secretary of the glass division would be glad to hear from any one willing to present data or construction details at the next annual meeting such that a half day's program on this single subject might be arranged and advertised.

MR. C. D. SMITH:—In speaking of producer gas Mr. Scholes refers to the weekly burning out of the gas line as the one outstanding drawback to this type of fuel. It is true that this burning out has its disagreeable features, but with gas mains of ample capacity, properly installed dust legs with a sufficient number of openings for blowing with steam or air and a good burnout connection to stack, this work becomes a matter of routine in which most of the disagreeable features disappear.

Mr. Scholes also refers to the luminous character of the flame from raw producer gas. The application of clean non-luminous gas, a mixture of producer gas and water gas, to glass tanks is being advocated in some quarters and from a fuel standpoint is a matter on which there is a difference of opinion. To my mind a luminous flame has undoubtedly merit in tanks as now built, and when a gas having a non-luminous flame is used the B.t.u. consumption may be expected to increase 30 to 40 per cent.

DATA ON VISCOSITY OF INDIANA CLAY SLIP WITH ELECTROLYTES IN REGARD TO THE CASTING OF TERRA COTTA[1]

By H. E. Davis

ABSTRACT

A presentation of data on the use of several electrolytes with one particular clay, to wit: Indiana clay, such as is used by the terra cotta manufacturers of the Chicago district.

The various electrolytes used were sodium carbonate, sodium silicate, the two combined half and half, gallic acid, and tannic acid. Data was obtained by determining relative viscosities with the use of a flow viscosimeter, and by measuring the thickness of wall cast in a given time.

Sodium carbonate, used alone, seemed to be the most satisfactory. Tannic acid shows possibilities, but so much is required as to be commercially impractical.

Introduction

The idea of casting terra cotta has been brought up numerous times, and no doubt one may safely say that almost every ceramist in the business has experimented with it at some time or other. From the results thus far obtained by others, and those made known thus far by the Bureau, the author came to the conclusion that the idea was quite impractical because of the greatly increased plaster cost, due to the slower turn-over of the moulds. However, the hope existed that some means might be found of economically casting such work as small free-standing ornaments, balusters, etc., which are the worst pieces in the business to press, and the poorest pieces when most painstakingly made. It is no doubt problematical, but furthermore, the author is inclined to believe that the more uniform and tighter body produced in the casting process would be more resistant to the spalling troubles prevalent in work of this nature.

References

In starting this study, no attempt was made to abstract previous publications on the subject, as it was thought quite unnecessary. However, there are two papers which should be mentioned: first, one by E. G. Acheson,[2] and one by Bleininger and Hornung.[3] Acheson's paper, being the first presentation of the subject in the *Transactions*, is very interesting and instructive. Starting into the clay business as a novice, he set about to add every organic substance he could think of to certain clays, and noted the effect of water on plasticity, shrinkage, strength, etc. He even used beer and claret and obtained satisfactory results in liquefying his mixtures. The 18th amendment having ruled these out, it was considered impractical to try them in these experiments. Mr. Acheson then called

[1] Terra Cotta Division, St. Louis Meeting, Feb. 28, 1922.

[2] Acheson, *Trans. Amer. Ceram. Soc.*, **6**, 31 (1904).

[3] A. V. Bleininger and M. R. Hornung, *Ibid.*, **17**, 330 (1915).

upon Dr. Heinrich Ries to corroborate his results, and the most important development in the research was the marked action of tannic acid, catechu, and emulsion of oat straw in liquefying certain clays. Dr. Ries found upon microscopic examination that the effect was produced by a dispersion or deflocculation of the larger groups of particles into the minimum size of individual grain, which greatly facilitated the liquefaction.

The second reference, that of Bleininger and Hornung, deals with the more modern method of preparing slips for casting by the addition of small percentages of sodium carbonate, and sodium silicate. In this paper the theory of electrolysis, and the hydrolization of the salts is very fully explained, and will not be gone into here.

Scope and Methods of Investigation

From a review of these two papers, it was decided to use the following electrolytes in connection with a clay from the coal measures of Indiana such as is used entirely by the terra cotta manufacturers of the Chicago district; sodium carbonate, sodium silicate, the two combined half and half, gallic acid, and tannic acid. As relative viscosity was all that was desired, a home-made viscosimeter very similar to the one used by Bleininger, with the elimination of the Marriot tube modification, served the purpose very well. In order to eliminate as much as possible any discrepancies, due to variation in head, the tube was filled to exactly the same level for each trial. The instrument used was a brass cylinder, 8.5 inches long, 2.5 inches in diameter, with a $^{7}/_{64}$-inch orifice in the bottom cap. The slip made up contained 76.2 grams of dry clay per 100 cc., which weighed in the slip state 148.5 grams.

Sodium Carbonate.—In the first series run, sodium carbonate was used in the following percentages: .02, .04, .08, .12, .16, .18, .20, .24, .30, .40, added in solution with a given amount of water to 800 cc. of slip. This showed a very marked effect after addition of .04%, but no effect whatever with .02%. The greatest fluidity was obtained with .16%, and higher percentages started the curve very slowly upwards, as can be seen from the chart. Even the most liquid slip produced showed no tendency to settle out heavily. The thinnest slip in the series was cast in a small crucible mould in order to determine the thickness of wall cast in a given time, and also the total time until the piece could be removed from the mould. The average wall at the middle of the cast was $^{7}/_{64}$ inches and the bottom was $^{1}/_{4}$ inch thick. Two and one-half hours from the time the mould was first filled were required before the cast could be removed.

Sodium Silicate.—The second series run was with sodium silicate in the same percentages as the carbonate, added in solution with the same

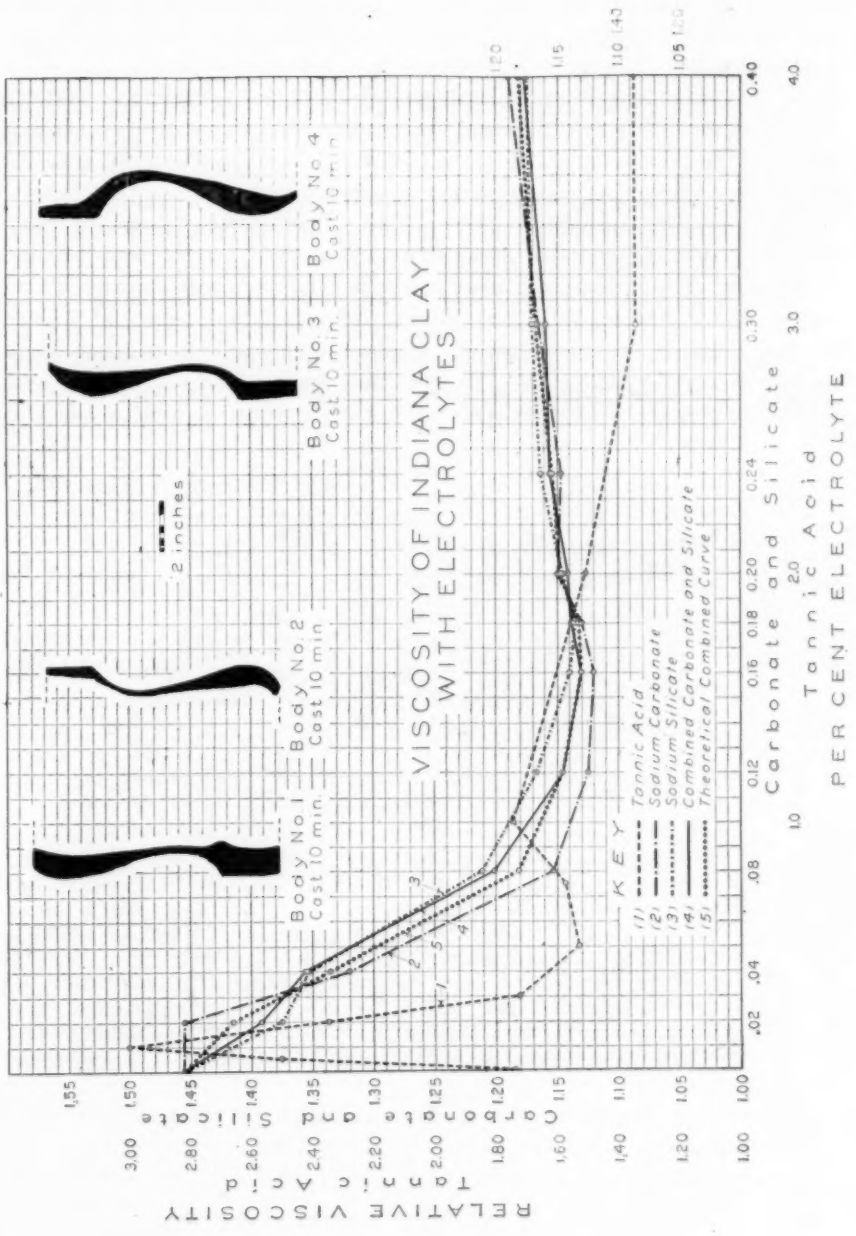
amount of water. The chart shows that this electrolyte was a little slower in acting than the carbonate, and required .18 per cent to produce maximum fluidity, which, however, did not reach the low point of the carbonate series. These slips were made up in the evening, and allowed to stand over night before running. By morning the bottom of each bottle of the thinner slips had about 1½ inches of clay settled so hard and gummy it was very difficult to get it into suspension again. The thinnest of this series and all others, except gallic acid, was cast in a mould the same as used for the carbonate slip for the same given time, and same results noted. In this case, the cast was removed from the mould in 1½ hours. The wall thickness was $^{10}/_{64}$ inch, and the bottom $^{17}/_{32}$ inch, which shows very clearly the rapid settling tendency. It is also noteworthy that the silicate with this particular clay allows it to free its water more readily than does the carbonate, thus producing a thicker cast in a given time.

Combined Silicate and Carbonate.—In the third series, sodium carbonate and sodium silicate were used in 50–50 proportions with quite satisfactory results. The percentages of the two combined were the same as those used for the individual components. The chart shows the combined curve to lie for the most part between the curves of the component electrolytes. As a matter of curiosity, a calculated curve was drawn up, and it is interesting to know that several of the minimum points coincide with the actual curve. Noting this, it was decided to measure the wall thickness of the casts from the three series with micrometer calipers. The results are as follows: Series No. 1 (carbonate) .116 in., Series No. 2 (silicate) .164 in., Series No. 3 (combined) .137 in. actual, .140 in. calculated.

Gallic Acid.—The fourth series was run using gallic acid solution as the electrolyte in the following percentages: .01, .02, .03, .04, .06, .08, .12, .16, .20, .24, .30, .40. Results from these trials, however, were very disappointing, and not even a curve was plotted. It was evident from the figures obtained in running the trials that the curve, had it been drawn, would not follow any definite trend, but would vary slightly from the plain slip, either up or down, with no apparent sense or reason. None of the entire series of twelve members showed any marked effect either toward thickening or liquefying the slip. Thinking that perhaps gallic acid was slow in taking effect, the slips were left until the following day, shaken well, and tried again. The figures checked very closely with those of the preceding day, so this series was given up as a failure.

Tannic Acid.—Following the results obtained by Mr. Acheson in his "Egyptianized Clay,"[1] it was decided to try tannic acid for its effect on Indiana clay. However, the range of percentage was made considerably higher than in the preceding, and the following members compose the

[1] *Loc. cit.*


VISCOSITY OF INDIANA CLAY
WITH ELECTROLYTES
RELATIVE VISCOSITY
Tannic Acid
Sodium Silicate
Carbonate and Silicate
Tannic Acid
PERCENT ELECTROLYTE
KEY
(1) Tannic Acid
(2) Sodium Carbonate
(3) Sodium Silicate
(4) Combined Carbonate and Silicate
(5) Theoretical Combined Curve
Body No 1 Cast 10 min
Body No 2 Cast 10 min
Body No 3 Cast 10 min.
Body No 4 Cast 10 min
2 inches

series: .05, 0.10, .20, 30, .50, .75, 1.0, 2.0, 3.0, and 4.0%, added in solution with a given amount of water. These slips were shaken thoroughly and allowed to stand 48 hours before running through the viscosimeter, as tannic acid is known to be slow acting. The results were rather startling. The first and second members increased the viscosity so that the slips were of such a muddy consistency they would scarcely run through orifice. The chart indicates very plainly this marked action and also the reverse effect of the next three members, which bring the viscosity down to the first minimum point. The following two take the curve upward, but it comes back, down to the minimum viscosity at three per cent tannic acid. Four per cent increases the viscosity slightly, so no further trials were made. It is important to note here that the thinner of these tannic acid slips were quite different in character from those of the series using other electrolytes, in that they maintained the clay in such perfect suspension and even with such a high water content showed no

TABLE I

No.	Per cent electrolyte	Rel. vis. sod. carb.	Rel. vis. sod. sil.	Rel. vis. combined
Water	..	1.000	1.000	1.000
Plain slip	..	1.455	1.455	1.455
1	.02	1.455	1.375	1.392
2	.04	1.320	1.353	1.356
3	.08	1.153	1.212	1.202
4	.12	1.125	1.167	1.146
5	.16	1.120	1.140	1.130
6	.18	1.130	1.135	1.138
7	.20	1.150	1.146	1.141
8	.24	1.147	1.163	1.156
9	.30	1.165	1.170	1.159
10	.40	1.190	1.175	1.177

TABLE II

No.	Per cent tannic acid	Rel. vis.
Water	....	1.000
Plain slip	....	1.740
1	0.05	2.508
2	.10	3.000
3	.20	2.350
4	.30	1.724
5	.50	1.530
6	.75	1.578
7	1.00	1.746
8	2.00	1.503
9	3.00	1.338
10	4.00	1.344

NOTE: A little heavier slip was used when this series was made up, which accounts for the higher viscosity figure for plain slip than in Table I.

tendency to settle over a period of several hours. This is clearly proven in the small casting made from the most liquid slip. The sodium carbonate slip cast in thirty-five minutes had a bottom more than twice as thick as the side-walls and the sodium silicate slip cast had a bottom more than three times as thick, while the three per cent tannic acid slip in the same time cast side-walls and bottom uniformly about $^{7}/_{32}$ inch thick, just twice as thick as the sodium carbonate slip, and was removed from the mould in one and one-half hours. A peculiar thing about this cast was the deep purple scum which appeared on the surface, due to the effect of light upon tannic acid, no doubt. This scum, however, dried to a hard casing, so hard it could *not* be scratched with the finger-nail. This shell was several thousandths of an inch thick.

Body Trials.—From the data obtained from the four successful series, four bodies were made up with grog for casting small balusters. These bodies were made as follows:

Body No. 1		
Indiana clay	20 lbs.	
Regular grit	10 lbs.	
Sodium carbonate	14.5 gr. or .16% clay	
Water	9.25 pts. (23.5%, wet basis)	

Body No. 2		
Indiana clay	20 lbs.	
Regular grit	10 lbs.	
Sodium silicate	16.25 gr. or .18% clay	
Water	9.00 pts. (23.0%, wet basis)	

Body No. 3		
Indiana clay	20 lbs.	
Regular grit	10 lbs.	
Sodium carbonate	7.25 gr.	16% clay content
Sodium silicate	7.25 gr.	
Water	8.5 pts.	(22.1%, wet basis)

Body No. 4		
Indiana clay	10 lbs.	
Regular grit	15 lbs.	
Tannic acid	4.75 oz.	3.00% clay
Water	4.75 pts.	(24%, wet basis)

Each slip was made up with the minimum water content necessary to permit casting, and was left over night so the electrolyte could take full effect. As time was limited, no special moulds could be made, and four old baluster moulds, pretty much weather beaten, were brought in from the yard for the trials. They were put in the dry box over night, however, so they were in the best shape possible, considering all other shortcomings. Into these moulds the four bodies were poured, and allowed to stand for

ten minutes only before emptying. Even with the moulds used, this was sufficient time to cast up a fair-sized wall, as is shown by the sections on the chart. Measured at the thickest part of the bowl the bodies cast as follows: Body No. 1, $1^1/_8$ in., Body No. 2, $^7/_8$ in., Body No. 3, 1 in., Body No. 4, $1^1/_8$ in. Measured at the neck, or narrowest part of the piece, the thicknesses were in order: $^3/_8$ in., $^1/_4$ in., $^5/_{16}$ in., and $^5/_8$ in. Body No. 2 was released from the mould in two hours and No. 4 was but little slower. Bodies 1 and 3, however, had to be left in the mould for a couple of hours longer, and even then were rather weak. This, I believe, is attributable partly to the position of the mould when casting. The sections on the chart show that Nos. 2 and 4 were cast with the large square base up, which left a large opening to facilitate in drying out the inside. The other two were cast with the bowl up, having only two very small holes, which I believe retarded the setting up considerably. However, the advantage of the open end with the particular mould used was at the same time a disadvantage in that the square base cast very thin on the flat side, and very thick in the corners. This, no doubt, could be overcome by proper design of the moulds for casting purposes.

Summary and Conclusions

From a study of the casts made from the plain slips, and from these same slips made up into grog bodies, certain things are evident, but too definite conclusions should not be drawn from the results of the work thus far. However, from the curve established and the cross-sections, we can safely make the following statements:

1. For casting bodies made up with typical Indiana clay, such as used by the Chicago terra cotta manufacturers, the best electrolyte, aside from tannic acid, is straight sodium carbonate, because,

(1) It produces maximum fluidity in the slip.

(2) It does *not* produce a slip which settles out heavily.

(3) When made up into a body, it casts a uniformly thicker wall than does the sodium silicate body, or one using a combination of the two.

(4) Although it was slower in drying out and releasing from the mould, this, I believe, was largely due to the shape of the mould, and can be overcome, or at least greatly improved.

2. Sodium silicate, when used as the sole electrolyte with Indiana clay, presents the following disadvantages:

(1) It does *not* hold the clay in suspension, but rather settles it out in a very hard, gummy mass in a short time.

(2) Made up in a body, even with a slightly less percentage of water than the carbonate, the wall of the baluster cast in a given time was thinner than with the latter.

(3) If allowed to remain in the mould longer in order to get a thicker wall, past experiments, not mentioned heretofore in this paper, have shown that a silicate slip will seal both next to the plaster, and on the inside, making a rather stiff shell with a soft center, which takes an incredibly long time to dry out.

3. Nothing further need be said about the use of half and half carbonate and silicate than that it produces a body, the properties of which are just about an average of those produced by the components.

4. The best results in many respects were obtained with tannic acid, and it has several things to recommend it.

(1) It makes a slip of excellent working qualities, holding a perfect suspension.

(2) Although the minimum viscosity attained was not nearly so low as with the others, it seemed to lose its water *much* more readily, as is evidenced by the large cross-section of the cast.

(3) The body when dried is very appreciably harder than any of the others. In fact it is so hard it cannot be scratched with the fingernail.

However, 3.00 per cent tannic acid is out of the question commercially as it would be entirely too expensive. Unfortunately no body was made up using 0.50 per cent of the acid, but the plan at the start was to select from each series one of the lowest viscosity, and no time was left for additional work, though it is quite evident that much more can be done in following up the leads so far uncovered. This work will include the proper designing of casting moulds, experiments with plaster to determine the maximum absorption, and possibly some further search for electrolytes among the organic acids, and it is hoped that much of this can be completed in the near future.

A study of the properties of various plaster mixes with varying water contents, and the introduction of adulterants of various types is now under way, and will be the substance of a future article by the author in which he hopes to correlate the information to be obtained to the data herein presented.

THE NORTHWESTERN TERRA COTTA CO.
CHICAGO, ILL.

Discussion

MR. W. D. GATES:—Probably I am the only one here who was present when Mr. Acheson[1] brought this question up. That was the first time that we had a paper sent out for reading before being read at the Convention. It was quite an innovation, and I remember distinctly the impression it made on me. I said to myself: "Here is a man who uses

[1] *Trans. Amer. Ceram. Soc.*, **6**, 31 (1904).

clay only incidentally as a binder in grinding wheels and yet he has made this great discovery. We have been asleep at the switch."

With a great deal of difficulty I got some of the material from some remote clime. I found that the least I could get was a bale. I got a bale. It was very interesting. It was done up in a mattress, one on top of the other, and it was much more than I wanted to buy.

I tried a few minor experiments with it, and it caught my attention because it rendered the molded clay unusually hard when dried. It occurred to me that the use of tannic acid would greatly reduce the breakage and chipping in the handling prior to burning if nothing more.

We were experimenting with some large sized bath tubs at the time, which gave an excellent chance to try it. We opened this bale and made a mixture and pressed a bath tub. Just then I started for the Convention full of enthusiasm regarding this new discovery.

When I returned home I found that the bath tub had formed a hard shell on the outside of the pressed parts, apparently sealing up the surface, and the ware was all torn with cracks and was ripped in every direction.

The proposition was very interesting in many respects, but I think that bale from India is somewhere about the factory now. The idea I had was to harden the raw clay so as to lessen breakage in handling, but the surface swelled and hardened, thus effectually so sealing up the pores that it was impossible to dry the piece. We did not go further with it.

I have never had good results with it, although I understand that it is used.

MR. DAVIS:—I understand, Mr. Gates, that you used catechu rather than tannic acid?

MR. GATES:—Yes.

MR. DAVIS:—We use tannic acid. Of course, we do not cast a very thick wall, but still there is an inch and an eighth, and there is no tendency to seal and to leave a soft center. Tannic acid does not do that. It forms a very hard shell, but it does not seal the surface.

MR. GATES:—It was catechu that I had. I could not remember the name. It is a gummy substance. We had a different condition from those described in Mr. Davis' matter. Catechu probably sealed the surface whereas tannic acid does not.

MR. THURLIMANN:—Catechu is used in medicine as an astringent, the same as tannic acid. Probably other organic astringents would have the same effect as tannic acid.

MR. GATES:—I might have better taken it as a medicine, probably.

MR. C. W. HILL:—It would seem that the casting of terra cotta on a production basis would be a valuable development, especially in the case of pieces like balusters which are difficult to press properly.

In experiments of this nature one wishes there were an easier and quicker

way of finding the best electrolyte than by actual casting trials. Possibly one could get a line on the nature of the electrolyte desired by determining whether the colloidal matter in the clay under investigation is positively or negatively charged. It would be of assistance if one could classify the electrolytes on some basis which would enable the investigator to concentrate his tests on those of one class. As an illustration it might be possible to classify them as to degree of acidity or basicity or hydrogen ion concentration.

If some systematic scheme could be worked out it would assist others who wish to do the same thing with clays of a different nature, whereas by the method of trial of a wide variety of electrolytes the results which Mr. Davis would get, while satisfactory for his clay, would not be of value to others unless they had the same kind of clay. However on account of the special properties of each colloid such as the specific absorption of certain ions it is not certain that even if classification were possible in one case the same classification would hold for another.

MR. ORTMAN:—In the case of tannic acid, it is not just like adding glue to the clay, which we know will make it very much stronger and which will hold it in suspension and act in some degree as will sodium bicarbonate and sodium silicate? We experimented with different electrolytes, catechu and tannic acid, and found that the strength of the dry pieces was increased four or five times. When we burned and tested the pieces they showed no evidence of the effect of the electrolytes.

MR. THURLIMANN:—The ionization factor of tannic acid is not very great. If it is hydrogen ion concentration that is wanted why not use hydrochloric acid which shows the greatest ionization?

MR. C. W. HILL:—My mention of hydrogen ion concentration was merely as an example of a classification and not as an explanation of any of Mr. Davis' results. The best electrolyte for any clay would depend upon its colloidal nature and possibly the presence of salts in the clay.

MR. DAVIS:—A strong acid as a general thing will increase the viscosity materially. The effect of increasing concentration of tannic acid is first to raise the viscosity to the maximum and then decrease it, there being two minimum viscosity points in the curve. You could not account for that by hydrolysis of the electrolyte.

MR. C. W. HILL:—It is quite common in colloidal chemistry to find the same electrolyte producing different effects at different concentrations. I would not know how to account for the change in this case.

MR. DAVIS:—Do I understand, Mr. Hill, that in your opinion tannic acid is not an electrolyte?

MR. C. W. HILL:—It is an electrolyte. My point is that if tannic acid shows promising results you might find other compounds belonging to the same class which would be better.

MR. C. W. HILL (Communicated):—Although the classification of electrolytes seems in this application to be desired but difficult to obtain, one can not help but wish there were a quicker way of testing the electrolytes. This is especially true if it is not possible to work by classification, since one would have to test a large number of electrolytes. Possibly a study of the effect on rate of settling would be a short cut.

On the general proposition of casting I should like to inquire whether the composition of the mould enters into the problem. It occurs to me that with plaster of Paris moulds the calcium sulphate which is somewhat soluble might have an effect which would not be found with some other porous material.

AN OIL-FIRED FURNACE FOR THE PLANT LABORATORY

By D. A. Moulton

ABSTRACT

Description of Furnace.—This is an iron-encased furnace with 1½-inch asbestos insulation. The chamber is 21 inches square by 20 inches high and will hold 14 bricks on end.

Operation of Furnace.—This requires from 16 to 20 gallons of fuel oil per heat of high temperature for a period of five hours. Pre-heated air is supplied by a No. 4 Blower running 3000 R.P.M. delivered through a 3-inch pipe.

In the *Transactions* and *Journal of the American Ceramic Society* several fusion furnaces have been described which have been quite small and require that the sample of clay or brick be tested in the form of a cone. There has always been a question as to the effect of reducing the brick to a powder because of the destruction of the texture of the brick. Often small portions of brick or cones cut from brick have been used for fusion tests, to observe the temperature at which trial pieces begin to fuse.

Fig. 1.

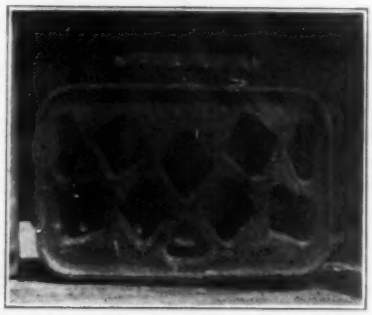


Fig. 2.

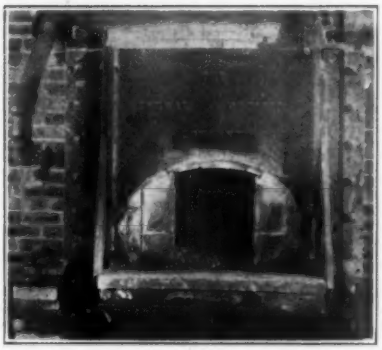


Fig. 3.

The furnace here described permits a test of the whole brick. It is large enough to hold fourteen bricks placed on end, and one cone pat. The chamber is twenty-one inches square by twenty inches high. It is oil-fired, the oil being fed to it by gravity under a head of eight to ten feet through a half-inch pipe. Two valves are used on the line, one a needle valve for accurate control.

The air is supplied by a Number Four Positive Blower, 3000 R. P. M.,

discharging to the furnace through a three-inch pipe. Nearly the full capacity of this blower is required to obtain a temperature of cone 34, or 3164 degrees F, as indicated by an optical pyrometer. Cone 34 can be

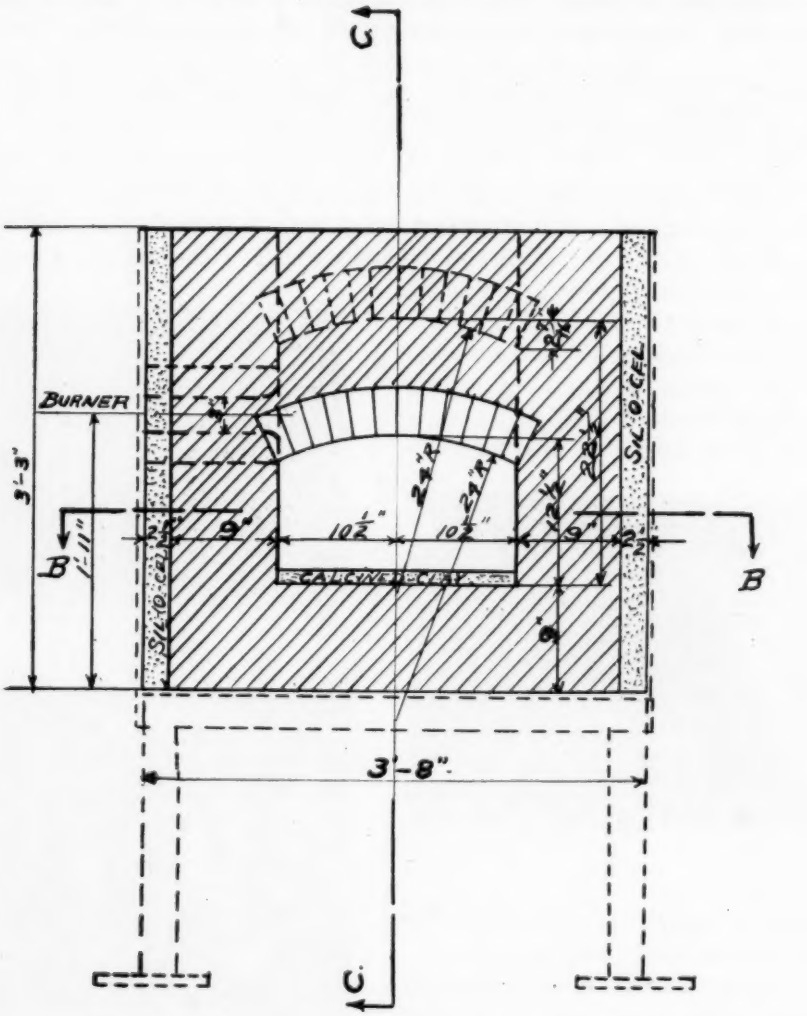


Fig. 4.

obtained in five hours. It is believed that this furnace could obtain still higher temperatures, especially with a larger capacity blower.

The burner seen in the sketch reduces the size of the pipe from three

to two inches. The two-inch pipe comes within four and one-half inches of the inside lining through a fire-clay nozzle block which flares flush with the lining. A peep-hole through the burner enables one to observe whether the pipe is clear or melted. If the pipe should collapse by softening, shutting off the oil for a moment will let the air blow it open again.

The oil is fed to this burner through the bottom into a ring which leads it to the top where it drops through a hole twelve hundredths of an inch

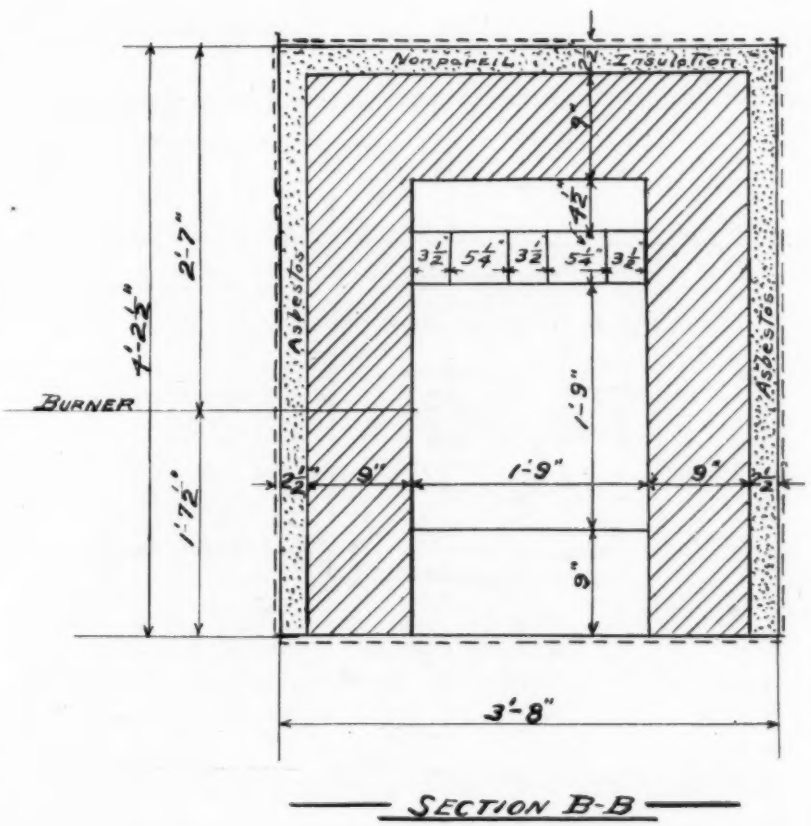


FIG. 5.

in diameter. This small hole admits plenty of oil but owing to the small bore it is desirable to screen the oil. It requires from sixteen to twenty gallons of fuel oil for each high temperature heating of five hours duration.

The air is pre-heated in two hollow castings placed over the outgoing flue or chimney. The two castings are alike but are placed end for end, thus staggering the openings. The air pipe just above the burner is so hot that a spray of water on it will sizzle.

The three flues to the chimney are five inches above the floor of the furnace and measure three and a half by two and a half inches.

The door of the furnace is built of fire-brick shapes. An opening in the door five inches square is closed by sliding a brick in front of it.

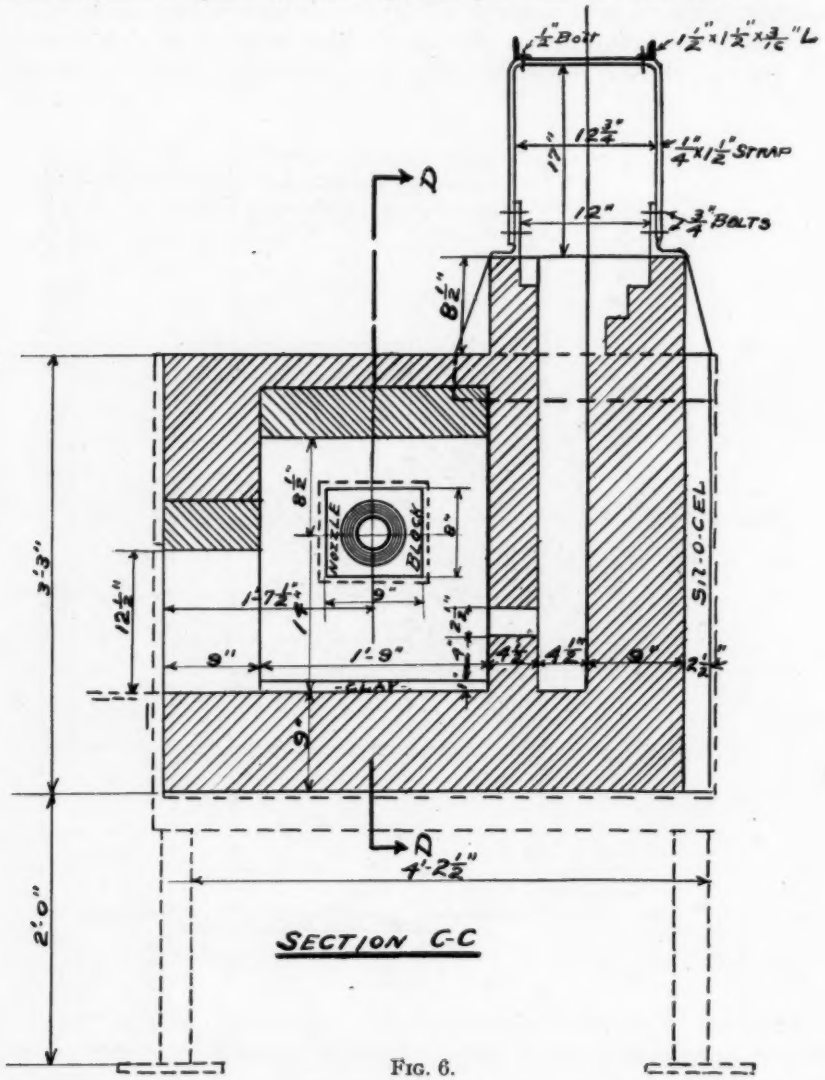
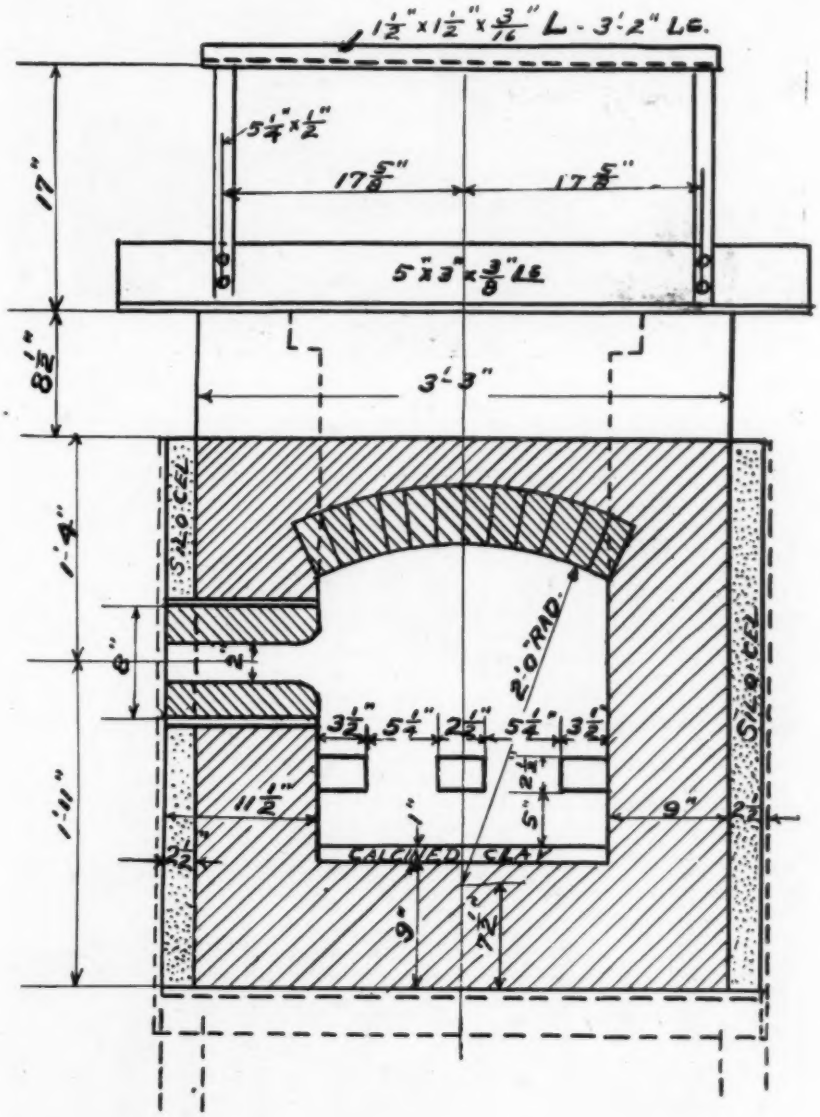


FIG. 6.

A time temperature curve of a test run in this furnace is shown in Fig. 9.

Results obtained in this furnace: Fig. 10 shows two bricks heated to 3125 degrees F, cone 32 down, and cone 33 starting. Both bricks are



SECTION D-D-

FIG. 7.

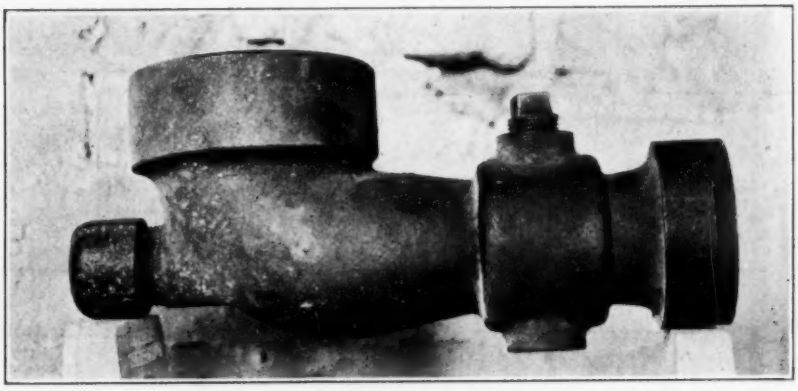


FIG. 8.

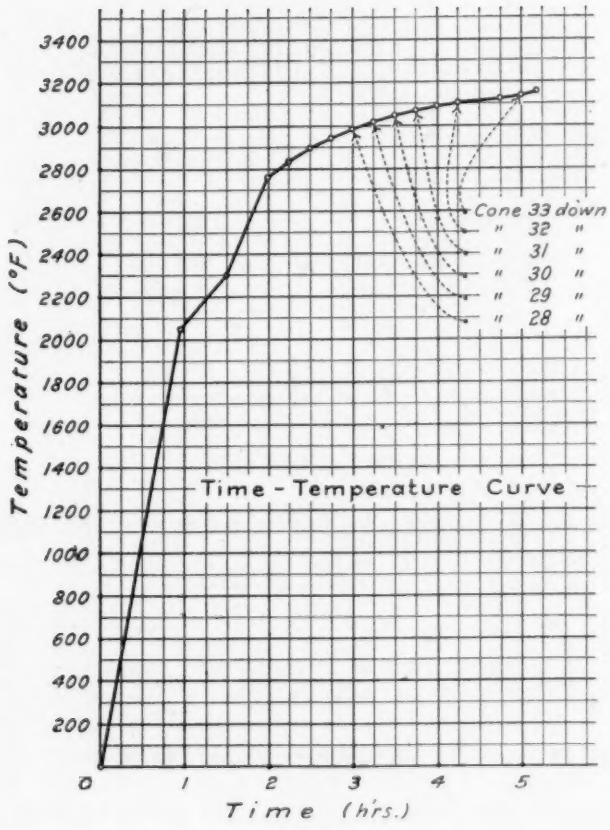

Temperature (°F)
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1
2
3
4
5
Time (hrs.)
Time - Temperature Curve
Cone 33 down
" 32 "
" 31 "
" 30 "
" 29 "
" 28 "

FIG. 9.

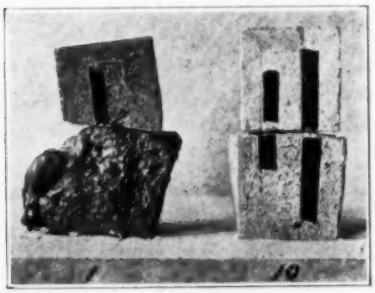


FIG. 10.

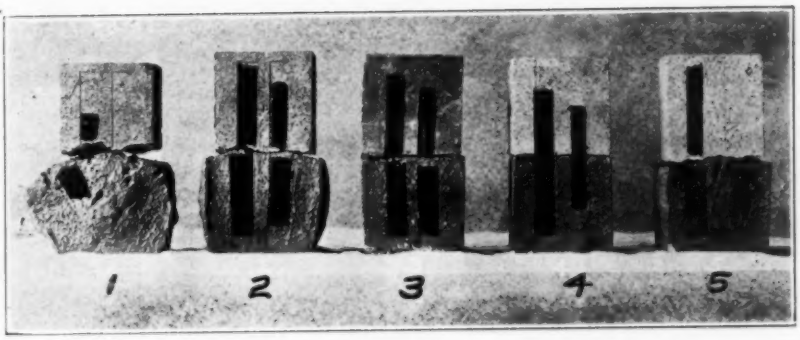


FIG. 11.

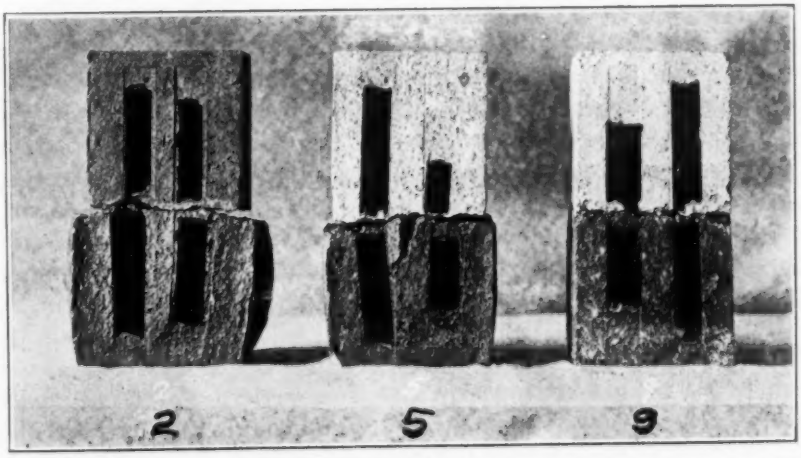


FIG. 12.

made by the stiff-mud process but at different factories The black streaks on the brick are simply obliterated trade marks.

Figure 11 is a good illustration of the effect of the process of manufacture from the same clay. No. 1 brick in this picture is, however, a lower grade of clay. No. 2 is made of the same grade of clay as No. 3. The only difference is in the process of manufacture, No. 2 being made by the stiff-mud and No. 3 by the dry-press process. The same is true of No. 4 and No. 5, both being made of the same clay which is a better quality than that used in making bricks No. 2 and No. 3. Brick No. 4 is made by the dry-press and brick No. 5 by the stiff-mud process.

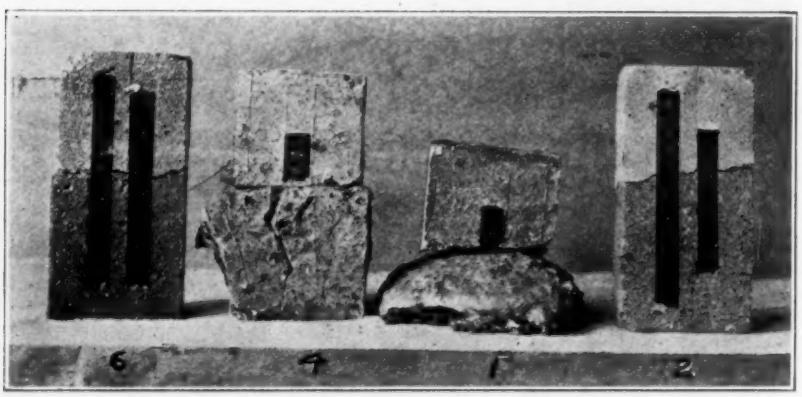


FIG. 13.

Figure 12 illustrates three brands of brick made by one firm, showing gradations according to refractoriness as graded on the market. The temperature of this test expressed in cones was cone 30 down and cone 32 starting.

Figure 13 shows two brick which were supposed to be made of southern bauxite but which melted to the above condition at 3115 degrees F, cone 32 down. Many lower grade fire brick and a few higher grade brick containing lime melt down into a puddle similar to this No. 3 brick.

This furnace may be used for running expansion tests, spalling tests, slag tests, and could be arranged for load tests.

DEPT. OF CERAMICS
IOWA STATE COLLEGE
AMES, IOWA

WATER SMOKING WITH INDUCED DRAFT[1]

By W. W. Ittner

ABSTRACT

Recitation of experience with induced draft shortening the periods of water smoking, burning of dry pressed brick and economizing on fuel.

Introduction

An article, "The Water Smoking of Clay," by R. F. Geller, appearing in the *Journal* for May, 1921, covered in a more scientific and thorough way work done along the same lines by the writer as far back as 1893.

In a cruder way, and without the aid of instruments, approximately the same ground was covered, except that in my case the work related to a particular product with the conditions of manufacture and the clay being worked, as a fixed quantity. Naturally the conclusions derived by the writer were not and can not even now be placed and presented in any such explicit and succinct manner. It does seem strange though, that a period of some 28 years should have elapsed between the time when the writer fought through his own little difficulty and the appearance of an experiment sufficiently related to attract attention.

Most clay workers have difficulty in differentiating between drying and water smoking due in greater part to a carelessness in the use of term rather than to any misconception of the subject.

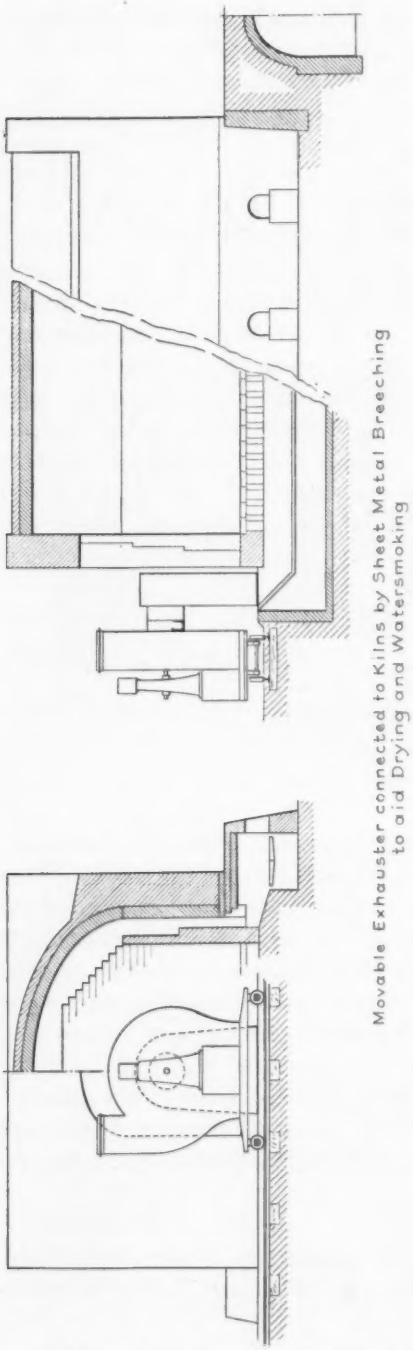
Water smoking, *per se*, is a distinct stage in the kiln process with but a "twilight zone" shading off from drying on the first hand and dehydration on the next. Confusion is brought about by a lack of distinct line between them.

The drying, if carried on in a separate dryer, and before the ware is set in the kiln, is easily distinguished from the water-smoking period. When both processes are accomplished in the kiln itself, there is no ending of the one and the beginning of the other, for both drying and water smoking are the evaporating off of mechanical water. The line between the two periods, in a given clay and under certain conditions, can be arrived at only when treating a single unit, as in Geller's experiment, rather than with an entire kiln of ware.

From a practical point of view, it is a fact that none of the separate stages into which we have divided the kiln operation occur separately and distinctly in a given kiln burn but proceed progressively as the temperature rises.

Geller's conclusions are, in my opinion, correct and of great practical value. He does not cover the practical application of his experiments, leaving this matter to the individual to apply to his own particular conditions.

[1] Rec'd March 27, 1922.



Movable Exhauster connected to Kilns by Sheet Metal Breeching to aid Drying and Watersmoking

We would have preferred more description of the success of each run as indicated by the physical condition of the clay cubes after treatment, than to have had the determining factor of success or failure hinge entirely on the thermal lag, both in regard to the penetration of the heat into the cube itself and the cube temperatures in reference to furnace temperature. The danger zone or period of greatest thermal lag is shown as lying between 100° and 250°C. However, the most severe treatment, shown by the first run in his Table I[1] in which the temperature was raised to 300°C in three hours, might, from a practical point of view, be perfectly all right, if no bad effects on the ware resulted and if it was desirable to water smoke the ware in so short a time.

It is with that portion of his conclusions referring to the use of induced draft that we expect to deal since it was through the use of this expedient that the drying and water-smoking periods were greatly reduced by the writer in length of time and at a great saving in cost.

What I have to say relates to dry press ware which is the more difficult to water smoke in a kiln as the bricks are set direct from the press into the kiln.

Description of the Case

At the time the writer took charge, it was taking some eight days for the drying and an additional eight days for the water smoking and burn-

[1] Geller, *Jour. Amer. Ceram. Soc.*, **4**, 377 (1921).

ing. The kilns were of the rectangular down-draft type with the tunnel and stack arrangements, as shown.

The drying was accomplished by the aid of an exhauster attached to the end of the kiln opposite the stack and was moved along on a track so as to serve any one of the battery of eight kilns standing in line. The exhauster was connected to the kiln tunnels by a sheet iron breeching, substantially as shown in the sketches.

TABLE I

SEVEN-DAY DRYING SCHEDULE

Hrs.	Period	RPM	Fires	Fuel	Rem.
6 12 18 24	24	100	Low as possible. End of sticks burning only in ash pits	Cord Wood	12 Cords of wood Apportioned
30 36 42 48	24	150	One stick all the way in. One-half way in	Cord Wood	
54 60 66 72	24	200	2 Sticks	Cord Wood	
78 84 90 96	24	250	3 Sticks	Cord Wood	
102 108 114 120	24	Full speed 300	One stick wood. Grates 1/3 covered	Wood and coal	Coal screenings used. Fires on grates
126 132 138 144	24	300	Grates 2/3 covered	Coal	
150 156 162 168	24	300	Grates covered	Coal	

The kilns had a capacity of 185,000 bricks, building size, and were set thirty-four high. Some sixteen to twenty cords of wood were being used in drying, besides an undetermined quantity of coal, after the wood was consumed. The brick were manufactured by the dry press process and of the usual red-burning surface clay.

The Experiment

It was apparent that too long a time and an excessive amount of fuel were being used in the drying and burning, hence, experiments were started immediately to reduce the drying and burning cost. The matter was gone about in a very cautious way, since up to that time the writer's very limited experience had been with the old style up-draft kiln.

TABLE II
ORIGINAL EIGHT-DAY BURNING SCHEDULE

Hrs.	Period	Fires	Fur. doors	Settle
6 12 18 24	24	Light and clear. 3 shovels	Open	
30 36 42 48	24	Light and clear. 3 shovels	Half open	
54 60 66 72	24	4 shovels	4″ open	
78 84 90 96	24	4 shovels	2″ open	
102 108 104 120	24	4 shovels	Closed	
126 132 138 144 150 156 162 168 174 180 186 192	72 hrs.	According to settle	Worked according to settle	Settle starts 1″ 2″ 2″ 2″ 2″

Without instruments of any sort to act as a guide, a schedule of drying and burning was laid out in such a manner as seemed to assure the most uniformity in the temperature increase and so as to save one day in both operations. This schedule was laid out in the form of a chart as shown in Table I. Progress of temperature increase during the drying was regu-

lated by the number of sticks of wood that were placed in the furnaces at a time and was varied only when the feel of the air from the exhauster indicated that things were moving either too fast or too slow. The drying operation was taken to be finished when no moisture appeared on a cold iron rod thrust into the lower peep-hole and when the exhaust air left the hand perfectly dry and hot.

The burning schedule, mapped out in the same manner as the drying schedule, was then entered upon (see Table II) and its progress regulated by the number of shovels of coal at each firing and later by the appearance of the heat after the kiln had gained sufficient temperature to admit of observation through top and bottom peep-holes.

The transition from the drying to the burning operation was made as evenly and regularly as possible by the gradual slowing down of the exhauster and at the same time drawing the stack damper until, in the course of six or eight hours, the exhauster was finally stopped and removed. By this time the stack was able to pick the kiln up and go right along with very little, if any, interruption.

After the kiln became red, so that the action of the fire could be observed, the schedule was varied according to circumstances. Sometimes the fire worked through to the bottom faster than at others and the settle started more promptly or more evenly in one burn than in another. These conditions were all met in the usual manner with increased or reduced charges of coal or by the arrangement of stack dampers.

The quality of brick that were being made was of the best of this grade and while it was absolutely essential to reduce the cost of manufacture it was also essential that the quality of the ware be not impaired. To this end each shortened schedule in the drying and burning processes was watched very closely and carefully so that any defect in the quality of the ware would be noticed as soon as possible until it would be evident that the danger point had been reached and further shortening of the drying and burning time impossible.

Shortening of Drying Time.—As an aid to the writer in shortening the drying time and to ascertain what the lower limits of time might be, a great many single bricks were dried and the time of drying noted by the simple means of placing the brick in the engine room over the cylinder of the engine and bringing them closer and closer to the cylinder in gradually decreasing periods of time. Contrary to the writer's expectation, single bricks could be dried in a very short space of time without damage to the ware, this period being as low as one or one and one-half hours.

We understood, of course, that an entire kiln of brick could not be handled with the same expedition and safety as a single brick; however, the experiments went a long way in giving assurance that the essential qualities for rapid drying were present in the clay and that a shorter time

in the kilns could be obtained if the proper methods of setting and drying were learned and adhered to. Accordingly the schedule for the drying in particular was gradually reduced to six, five and then to four days (see Table III) and the amount of wood, which was the more expensive fuel, reduced to three cords, when it was concluded that the end had about been reached.

The four-day schedule, which was half the original time of drying, was adhered to for quite a while until further demands on capacity (with a consequent indifference to quality) called for further reduction of time. The drying operation was carried on for several years in succession on a three-day schedule, and in several particular instances, where all condi-

TABLE III
FOUR-DAY DRYING SCHEDULE

Hrs.	Period	RPM	Fires	Fuel	Rem.
6			One stick all	Cord	3 cords of wood
12	18	150	the way in.	Cord	Apportioned
18			One, half in	Wood	Apportioned
24					Fires in ash pits
30	18	200	2 sticks	Cord	
36				Wood	
42		Full	Grates 1/2		Coal screenings
48	24	speed	covered	Coal	Fires on grates
54		300			
60					
66					
72			Grates		
78	36	300	covered	Coal	
84					
90					
96					

tions were undoubtedly favorable, kilns were dried in two and a half days with no material damage to any excepting to tight courses. The brick from the tight courses were weak and without the metallic ring, although they left the plant as salable ware at the time.

Shortening of Burning Time.—While the drying point was shortened as described, our success in shortening the burning time was not attended with any such gratifying results, since seven days was about the least time in which the kilns could be burned and proper results obtained.

The most critical time was between the conclusion of drying (when the exhauster was removed) and the time the kiln became red. We discovered that too rapid a rate of raising the temperature during this period caused the brick to lose the metallic ring and were damaged by quashing, showing false settle; and by the kiln settling unevenly. This period of

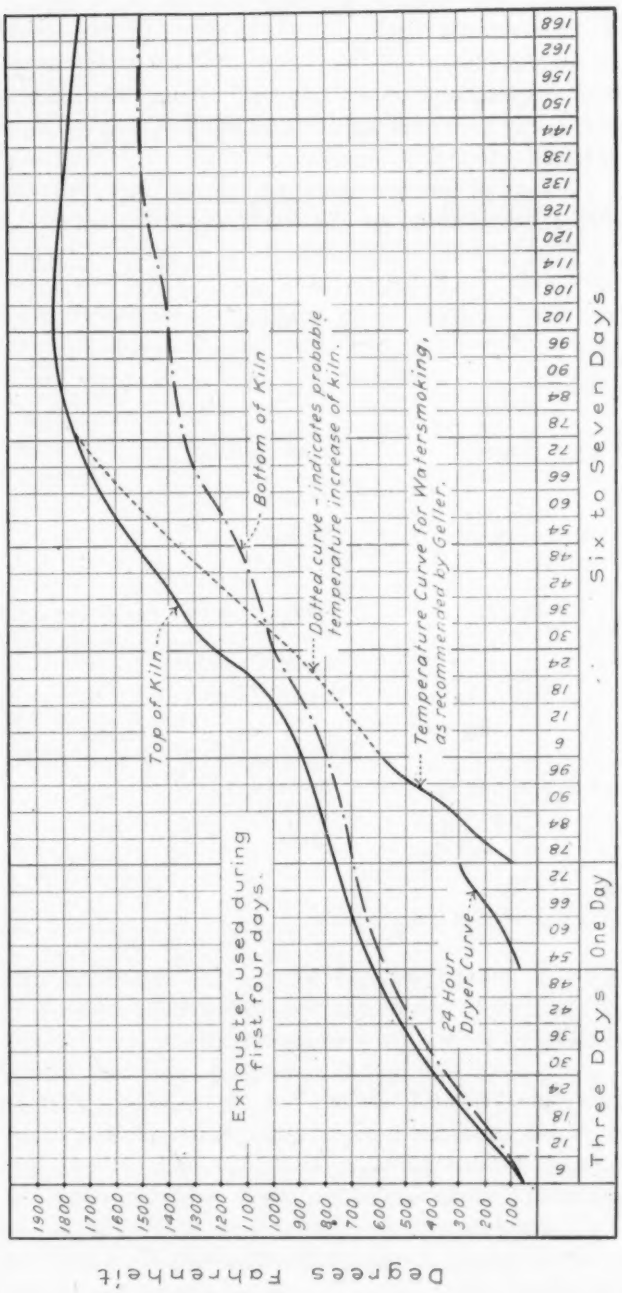
burning was changed to give a slower advance with the stack draft immediately after the exhauster was removed, for perhaps 24 to 36 hours. The forced firing was then resumed until the kiln was "sweated" or evened up in temperature preparatory to starting the settle. Naturally after the settle was started the fires were worked and the kiln governed entirely by the rate of settle.

In shortening the time of burning after the kiln was dry, our sole aim at the time was to effect as rapid an increase up to the point of settling

TABLE IV
SIX-DAY BURNING SCHEDULE

Hrs.	Period	Fires	Fur. doors	Settle
6 12	12	4 shovels	Open	After only 3 days drying, this was too fast an increase
18 24	12	4 shovels	Half open	
30 36 42	18	4 shovels	4″ open	
48 54 60	18	4 shovels	2″ open	
66 72 78 84	24	Heavy—so as to reach settling heat	Closed	Settle starts
90 96	60 Hrs.	According to settle	Worked according to settle	1″
102 108				2″
114 120				2″
126 132				2″
138 144				2″

as could be accomplished in an even and regular manner. That seemed to have been our fetish—"no matter how rapid, if it was done in an even and uniform manner, it must be all right." We had yet to learn that uniformity was not the whole secret and that some stages of the kiln operation could be carried on at a very much more rapid rate than others. To this end the schedule was changed from the chart shown in Table II to the one shown by Table IV. It was by following the Table IV schedule that bad results were obtained; the forced firing, following immediately



Average Temperature Curve, taken from Pyrometer Charts of several Burns
Top and bottom readings shown.

after the kiln was dry, was entirely too fast and quashed, and shaky brick were the result. Our diagnosis was "heating up too fast."

The schedule was then changed, and the kiln was given a slower rate of increase for the first few watches and then a faster rate taken after the lower peep-hole became dull red. We found that it was impossible to do this and complete the burning in six days, so a seven-day schedule was adopted. We also found that time could be saved and good results obtained by holding the exhauster on as long as possible, for another 18 to 24 hours, or until it became so hot that it was absolutely necessary to take it off to keep it from being destroyed.

Examining the chart, which shows an average of the temperature increase of several kilns recently dried and burned, it must be evident from the temperatures shown, that most of the upper courses of brick have gone through, not only the drying but also the water-smoking process, long before the third and fourth days are reached: either that, or else there is a terrific thermal lag between the kiln temperature and the temperature of the interior of the ware.

Conclusions

In drying the kilns as rapidly as is shown by the chart, it can not be maintained that there is not a considerable lag in temperature; however it can be maintained that this lag is not great enough to damage the structure of the brick, from the simple fact that the brick were sound and with clear metallic ring.

The first theory mentioned above, then, must hold true; or as expressed in one of the early paragraphs of this paper, the various processes do not occur separately and distinctly in relation to the whole body of ware but commencing at the point nearest the source of heat, they follow one another consecutively, the one gradually merging into the next as the temperature increases.

Certainly the writer's experience coincides with Geller's conclusions, that is, that more rapid and safer water smoking can be accomplished with induced draft. In our case, the induced draft was used primarily as an aid to drying. The brick were in the kiln in which they were to be burned, and, as a consequence, the whole kiln structure was heated as the drying progressed: also the stack draft was established. If it was of benefit, under these conditions, how much more beneficial induced draft might be where brick, even thoroughly dried, are placed in a cold kiln and the fires lighted with draft currents, negative or reversed, can only be surmised.

In conclusion, the writer's experience would indicate that a light portable exhauster, arranged for easy attachment to kiln or to the tunnel between the kiln and stack, would prove economical in many plants.

Discussion

Mr. W. W. ITTNER:—I have seen a good many articles, but I have not seen anything that struck me so forcibly as this article of Geller's applying to the manufacture of brick. Most of the articles and most of our efforts, I think, have applied to the higher branches, glass and pottery and that sort of thing, and it reminds me that we can have so many leaves on the trees as not to be able to see the foliage, and things get by us. We do not see the squirrels, for instance, but I think I have a squirrel here.

Geller speaks about dry press ware having to be handled much more carefully than other kinds. I do not know whether our clay dries exceptionally easy or not, but we have not had any difficulty whatever in drying and my experience (with different clays) is that dry press wares, do not show any particular difficulty in drying. In talks with other people, I find that that experience is more or less borne out.

Mr. TEFFT:—I want to thank Mr. Ittner for this paper because he at first did not think he had enough to talk about, but I personally believe "Water Smoking with Induced Draft" is one of the big things we are all going to come to.

A MEMBER:—What size fan did you use?

Mr. ITTNER:—What they call a No. 80. About thirty-inch intake and about a twenty-four inch discharge. Its maximum speed was about three hundred and fifty revolutions.

Mr. TEFFT:—What was your finishing temperature of the burn?

Mr. ITTNER:—We started settling at about 1700°, and 1775° is about a finishing temperature.

Mr. TEFFT:—I was asking that for the reason you gave the burning time as seven days. Did you make an attempt to put the exhaust gases into the chimney?

Mr. ITTNER:—No, the fan discharges right into the air. The kilns were all in line, eight kilns.

It is really remarkable the saving in time accomplished by this method. The only thing that would make other results differ from ours is that our kilns were old and they did not have sufficient grate surfaces. The earlier kiln designers did not know what adequate grate surface was. Later kilns have almost twice as much grate surface as we have.

A MEMBER:—What size motor did you have?

Mr. ITTNER:—It was an engine. An engine-driven fan is a pretty expensive proposition.

Mr. TEFFT:—At our Darlington Plant we are burning face brick entirely with induced draft, having no chimneys or stacks but discharge the gases from the burning kilns direct into the open. Our brick is made from a No. 2 grade of fire clay that finishes at cone 10. We are getting this cone down in the top of the kiln and are getting cone 8 down in the

bottom of the kiln, the kilns being set on edge 34 brick high. The brick made are of a high grade buff and manganese gray of face brick quality. They are being burned in six days' time and we run very close to this schedule at all times because of the draft system in use. This system does not vary from day to day or from summer to winter but is constant and we can control the draft in our kilns almost at will. We are shading our brick to a close shade and it is quite often that we get as high as 75% one shade on a smooth speck brick.

A MEMBER:—Do you use a drier?

Mr. TEFFT:—Yes, we use a drier. This drier receives its heat from radiation obtained from cast iron pipes running underneath each drier track. These pipes are a continuation of the main flue which supplies draft to our kilns—that is, the fan supplying draft to the kilns is put on the cold end of the drier and all combustion gases are pulled from the kilns through the main underground ducts to the hot end of the drier where they enter cast iron pipes and are pulled through these pipes underneath the drier cars and by radiation from these pipes we are able to dry our brick very successfully. The discharge gases from the fan pulling these gases underneath the drier tracks are quite uniform in temperature, being 320°F.

A MEMBER:—Do you have a fan between your kiln and the drier?

Mr. TEFFT:—No. The kiln is between the flue and the fan. The burning gases do not come in contact with the brick in any case.

A MEMBER:—Doesn't the sulphur in the coal eat up the fan?

Mr. TEFFT:—We have had a fan for six years and no trouble.

A MEMBER:—Do you burn with coal or gas?

Mr. TEFFT:—Both, mostly with gas—natural gas.

A MEMBER:—You are using cast iron pipe?

Mr. TEFFT:—Yes, sir, cast iron bell-joint pipe.

TERRA COTTA PROBLEMS SUGGESTED FOR DISCUSSION AND INVESTIGATION[1]

By C. W. Hill

ABSTRACT

An occasional review of the manufacturing problems of any industry regarding which positive information is fragmentary or lacking is often of value. Such a review of some of our terra cotta problems may be productive of discussion which will bring to light unpublished data and may inspire our industrial ceramists to increased activity in fundamental research. It may also be of value to our University friends who are frequently in search of research problems of a practical nature. Naturally any summary prepared by an individual will not be complete but the omission of points which others regard as important will usually be noted and supplied by discussion.

The following subjects are proposed for discussion and investigation:

I. Plaster
II. Materials: (*a*) Body mix and materials, (*b*) barytes, (*c*) grog
III. Glaze
IV. Process
V. Patching
VI. Service problems.

I. Plaster of Paris

Since plaster of Paris does not enter into the body or glaze and hence does not directly influence the ware, it apparently has not received much attention from terra cotta ceramists. The tendency has been to require plaster manufacturers to supply a quality of plaster which will satisfy the workers and the foreman. The standards of the A. S. T. M. are not especially applicable to plaster for our use. A complete set of specifications based on actual tests would be of value to the industry. It is, of course, necessary to bear in mind that local shop conditions influence the qualities desired in plaster. The setting time may differ between a shop having piece work systems and one paying by the hour, or between one in which a moulder works on one mould at a time and one in which he carries several moulds at once. The relation of physical properties, as shown by tests, and the strength, absorption, warping and chipping of moulds has apparently not been established. The selection of the best possible plaster, considering cost of plaster, volume of set plaster per pound, efficiency in use, cost of repairs, and life of moulds would doubtless effect a considerable saving to a factory during a year.

The possibility of adding agents to plaster so as to increase the rate or extent of absorption of moisture from the clay without undue decrease in mould strength is a most interesting subject for investigation.

The development of proper apparatus for uniform gauging of plaster and the supply of gauged plaster to the worker, while largely a mechanical

[1] Read before the Terra Cotta Division, St. Louis, Mo., Feb. 28, 1922.

problem, is one which requires a familiarity with ceramic problems. It would seem to be a matter quite promising of practical results.

At present costs the question of recovery of used plaster is one of commercial value when several plants are located fairly close together. Theoretically, there is no reason why the plaster can not be recovered. It should be possible to do this on a commercial basis provided enough waste plaster is available in a locality to warrant the cost of the installation. It would apparently not be profitable for any individual plant. Some efforts to reclaim plaster have been described in the literature, the common result being a plaster of low strength due to the presence of a high percentage of anhydrous sulphate. A careful study of vapor pressure would indicate the requirements of a suitable process. These processes may be outlined qualitatively as a means of heating a mass of plaster to the desired temperature for conversion without loss of moisture, removal of moisture under control and cooling under control. The fineness of the product would require the same attention as in the manufacture of new plaster. Deviations in properties of recovered plaster could probably be compensated by mixing before use with a suitably selected fresh plaster. The commercial possibilities of the process are, of course, related to the price for new plaster, freight rates, cost of coal and availability of a sufficient quantity of waste plaster in the locality.

II. Body Mix and Materials

The subject of body mixtures and materials has, of course, been studied by each plant as dictated by its available clays and the plant equipment and process. The relation of body composition to strength, porosity, expansion, etc., is being made the subject of investigation by the Bureau of Standards with the coöperation of the National Society and need not be discussed here. There remain, however, certain points of general interest which merit investigation.

Barytes.—Many manufacturers of ceramic products have found it necessary to add barytes to fix the large amount of soluble salts in their clays. Others, who have but small amounts of soluble salts, add barytes to be on the safe side, without having determined the efficacy of the addition or the amount required. Some are knowingly adding barytes in excess since it is rather difficult to watch the amount of soluble sulphates and any great increase might not be detected until quite a tonnage of ware was pressed and in the dryers.

Some manufacturers purchase barytes on specifications based on chemical analysis while others make only a qualitative test. Chemical tests of barytes are not sufficient guides for purchase for the reason that the activity of the barytes is not entirely dependent on its purity. The fineness and method of preparation influence the extent to which it will react with

soluble sulphates. The effectiveness of barytes is extremely doubtful in cases of low concentration of sulphates. The percentage of sulphates necessary to give rise to trouble has not been established. Some of these points have been investigated in our laboratory and will be made the subject of a larger paper when the work has been completed. The indications are that a considerable amount of money is being spent for barytes unnecessarily.

M. E. Gates[1] has discussed the use of barium hydroxide in place of barium carbonate. While the superiority of the hydroxide can hardly be doubted, the point was not established experimentally in Mr. Gates' paper which dealt primarily with a suitable apparatus for the use of hydroxide.

Grog.—The investigations of Clare and Albery[2] have shown the importance of further work on the nature of the grog and of the use of grog of controlled sizing. Additional investigation should, if possible, have results expressed quantitatively in terms of physical properties of the body as well as qualitatively in factory terminology. Some assistance on the problem may be anticipated from the work now in progress at the Bureau of Standards.

Wilson[3] has suggested the further investigation of grog sizing particularly with reference to slip cracking.

Davis[4] in an admirable paper has shown the effects of using grog of definite screen size and suggests the study of grists.

Flux.—The tightening of the body by additions of suitable fluxing agents is an interesting field for investigation. The subject will be discussed later, since papers on this subject have been promised.

III. Glaze

Investigations on terra cotta glazes have been extensive but the reports as published unfortunately do not as a rule present sufficient data to permit of duplication or of practical use. This is due largely to the failure to give the chemical analysis of feldspar used or to express formulae in the accepted XRO, Al_2O_3 Y SiO_2 manner. In some cases the expression has been given in this form but the feldspar has been calculated to the theoretical feldspar formula. It is common knowledge that even feldspar from the same mine varies sufficiently in content of free silica and in alkali content and ratio as to make the direct substitution of material from one carload for that from another shipment impossible. It is commended to

[1] Gates, M. E., *Jour. Amer. Ceram. Soc.*, **3**, 313 (1920).
[2] Clare, R. L., and Albery, D. F., *Ibid.*, **3**, 384 (1920).
[3] Wilson, Hewitt, *Ibid.*, **3**, 114 (1920).
[4] Davis, H. E., *Ibid.*, **3**, 641 (1920).

the attention of our writers and editors that papers on glaze should contain chemical analyses of feldspar and that glaze formulae should be expressed on a common basis. This will be a decided advantage although it will not tell us all that we should know, since the chemical analysis does not indicate the amount of free SiO_2 as distinguished from that which is combined.

Tenacity.—The subject of glaze tenacity and of the degree of penetration or union with the underslip or body are all of great importance. The microscopic method is the common method of attack and while it is productive of a great amount of information it is unsatisfactory in many respects. On account of the apparatus required this is a subject for university research along physical as well as chemical lines. Undoubtedly the use of underslip renders the problem more difficult and probably tends to lower glaze adherence.

IV. Processes

The processes of mixing, ageing, forming and drying are well understood in a practical way. While our information could be increased by further research it would seem that other manufacturing problems are more pressing.

The burning presents many problems of both theoretical and practical value. One of the most important is the determination of the critical cooling ranges of the burned ware. While these may vary somewhat with the different bodies it is quite probable that bodies maturing at the same temperature will have approximately the same characteristics in this respect, assuming no great difference in tightness of body. Doubtless our product may be cooled rapidly through certain ranges while in other zones the cooling must be slow or dunting will follow.

Hill[1] has discussed the results of Purdy and Boeck and has suggested 650°–500°C as the critical zone, more as a result of deduction than that of experimentation with a typical terra cotta body. With periodic kilns the point is not as important as with tunnel kilns in which full advantage may be obtained of rapid cooling. The use of tunnel kilns will doubtless bring out the critical ranges as a result of long experience and operation, but the ranges could be determined experimentally much quicker and at lower cost. R. L. Clare[2] has done some work which leads him to favor a tempering of the ware.

On account of the relatively small amount of free silica present in the body it is not to be anticipated that changes due to the transition of silica from one form to the other plays an important rôle. Likewise the analogy which some investigators have attempted to draw between clay ware and

[1] *New Jersey Ceramist*, **1**, 73 (1921).

[2] Private communication.

glass is extremely doubtful since the similarity of the bond to glass (a homogeneous solid solution) is probably masked by other factors. However, it is recognized in all plastic compositions that the characteristics of the bonding material frequently influence the properties of the mass far beyond the proportion which the bond bears to the mass of the inert constituents. These speculations would lead to a study of the characteristics of the bond and inert material separately as well as those of two variables together.

Considerably more research and engineering is required on tunnel kilns before they may be acclaimed a success for terra cotta. It would seem that better and less expensive types than the muffle tunnel kiln are commercially possible. This may be seen by the following considerations.

The rôle of the muffle in our intermittent kilns is largely that of protection against flame and ash. A muffle also offers a partial protection against the reducing gases. On account of the fact that all commercial refractories when hot are permeable by gases, there is a tendency for all flue gases to diffuse into the muffle. Usually there is sufficient access of air to the muffle to oxidize the CO and hydrocarbons and to prevent the reducing action of SO_2. SO_2 is usually present in a muffle during the certain parts of the burn and although it may issue from the parts in concentration sufficiently to be stifling, it does not do harm to the glaze as long as oxygen is present. With the usual design and operation of kilns the diffusion through the muffle free from leaks is not in excess of the amount which can be oxidized by air drawn into the muffle, except during the latter part of the burn when CO is frequently found in percentages as high as 0.2%. Ortman[1] reports as high as 1.6% but this could hardly have been obtained under good conditions.

This leads naturally to the assumption that terra cotta can be burned without a muffle, provided it it protected from flame and ash and that the flue gases which come in contact with it are the products of complete combustion with a slight excess of air. These conditions are found in the surface combustion type of furnace. A wide variety of slips and glazes were fired in a surface combustion kiln, the fuel being city gas. It was found that the colors were exact duplicates of similar burns in a muffle kiln. A further test was made using unpurified producer gas from anthracite coal, care being taken to insure an excess of oxygen. It was found that the SO_2 under these conditions had no effect on the glazes or slips. Among the slips and glazes tested were several containing iron oxide which had been found to be somewhat sensitive to improper kiln conditions.

A kiln of the surface combustion type would possess the advantages of simple construction with comparative low cost, and should be more efficient since the ware receives the heat directly without the interpolation

[1] *Jour. Amer. Ceram. Soc.*, **3**, 487 (1920).

of the muffle. The absence of the muffle should result in a shorter kiln and less difficulty from overlapping of temperature zones. It is to be expected that a kiln of this type should give less fire-cracking since the heat is transmitted to the ware by convection of the burned gases instead of radiation from the muffle and is taken away in cooling in a similar manner. The temperature gradient within the piece is therefore much less than when it is heated by radiation and, by proper design and control the gradient between the flue gases and the ware can be made quite long.

Theory and experiment, therefore, point to the possibility of burning terra cotta in a tunnel kiln without a muffle and with results not to be expected in a muffle kiln. While other means of securing complete combustion without flame may be possible of development, that of surface combustion is the only one with which the writer is familiar. The adaptability of the system to large sized chambers has been proved in other lines of work as well as the absolute control and constancy of the kiln atmosphere.

The preliminary results of trials with surface combustion kilns for terra cotta are sufficiently encouraging to warrant a most careful investigation by the individual manufacturers before going ahead with the muffle type of tunnel kiln.

The installation cost appears to be about 50% more than that for intermittent kilns of the same capacity and not more than half that of the muffle type of tunnel kiln. The labor cost of operation should be about the same as the muffle tunnel kiln, burning the same fuel, whereas the efficiency from a thermal-time standpoint should be much higher. On account of the lower temperatures and absence of flame the life of the simple refractory shapes should be very long indeed. The repair should be a comparatively simple and inexpensive matter.

Patching.—The repair of pieces scarred or chipped in shipping where mechanical strength of the piece is not impaired or where there is no danger from the infiltration of water when placed in the building, is a matter frequently of saving an expensive piece of ware. The development of a completely satisfactory cement would be of great value to the industry. The requirements are that the cement be capable of use by the average artisan, and that it have permanency of strength and color. Many cements change color on weathering, making an unsightly blemish on the piece. It may not be amiss to appeal to all terra cotta ceramists to publish their investigations on patching cements. It is quite probable that some manufacturers have developed a better cement than others and are inclined to regard the information as a trade or company secret, not realizing that the use of an inferior cement by any company injures the business of all companies. As a research matter the application of dental cements to this purpose offers a very attractive field. A complete

survey with comparative tests of all the cements given in the literature for ceramic ware or stone, and those now in the market would constitute a valuable contribution to our section.

V. Service Problems

The effect of lime and other components, method of preparation and application on the permeability, shrinkage, and strength of cements used for setting terra cotta is a subject of vital importance to the industry. While much can be done by proper construction and by the use of flashing for exposed work, the joints still afford a means for the introduction of water into a terra cotta wall and a large percentage of the failures attributed to terra cotta have been due to the admission of water through poor mortar. Although it might be said that research along this line is not within our field it is certain that investigation is needed and that we are all as much interested in knowing what is the best mortar obtainable as any one else can possibly be.

Along the same line it should be noted that many terra cotta manufacturers are still showing construction details which cannot fail to give trouble from the introduction of moisture. The chemist can be of assistance to his company by emphasizing the need of protecting iron from corrosion and the danger of cracking of terra cotta due to the expansive force of rusting iron imbedded in terra cotta which may become moist.

Atlantic Terra Cotta Co.
Perth Amboy, N. J.

MANUFACTURING CLAY PRODUCTS 14,000 FEET ABOVE SEA LEVEL[1]

By E. O. King

ABSTRACT

A description of the clays and methods employed by an American mining and smelting company in the Andes Mountains for the manufacture of common and refractory brick.

Several of the large American mining and smelting companies in South America operate their own brick plants because the transportation of ceramic products from the United States requires much time and the losses due to breakage from handling en route are very heavy. Brick shipped from the States must be carefully packed in heavy cases or barrels in order to withstand the rough handling which they undergo in oceanic shipping. From date of requisition to time of delivery usually means a period of three to six months. Upon arrival at their port they are loaded into lighters and taken ashore. Native transportation from the coast to the smelters in the mountains is a slow and costly proposition. Quite often the purchaser finds upon unpacking his material that part of it is of inferior quality which probably failed to pass inspection for home trade. With these problems to contend with the various companies have found it more satisfactory and economical to manufacture the majority of their requirements from local materials.

One of the above mentioned companies successfully operates its own plant in the Junin District of Peru at an altitude of 14,300 feet. This plant, originally built for the manufacture of common brick, was later converted to produce fire brick and silica brick. No definite capacity is maintained, the output being governed entirely by general construction and smelter requirements.

The equipment now consists of a jaw crusher, crushing rolls, two eight foot wet pans, a steam heated rack dryer and power repress. A small shaft lime kiln and four round down draft kilns—two 27 feet and two 30 feet in diameter—equipped to burn either coal or oil complete the layout.

The class of labor available in this section is the "cholo" Indian. They are a low type mentally and seem quite incapable of grasping the duties attached to more than one job at a time. Having learned a job they will stick to it and perform the duties in a mechanical way until removed. Little labor trouble is experienced and the turnover is very small year in and year out.

Common Brick.—The average deposit of common clay in this section contains lime in such quantity as to render it unfit for brick manufacture. The workable clays are found on the sloping pampas where natural weather-

[1] St. Louis Meeting, Feb., 1922.

ing has removed the lime. These deposits are lean, sandy and carry large quantities of small quartzite particles.

This clay is ground in wet pans and then hand moulded by the soft mud process. After drying the brick are burned in down draft kilns, coal being used as fuel.

Modern stiff mud machinery was installed on a new construction job with the intention of using this same type of material. The clay being very short made it impossible to form a proper column and the brick were very tender to handle. Wear on the die liners and auger tip was excessive, these parts being completely worn out before 200,000 brick had been run. Burning in updraft kilns with coal proved unsuccessful since cold air admitted to the arches during cleaning period chilled the rocky content so that the resultant product was weak and spongy. To eliminate the cleaning periods oil burners were installed and a fair product was obtained. Recently other deposits, free from the rocky particles, were discovered and are being worked successfully by the stiff mud process.

Fire Brick.—The fire clays of this section are found at an altitude between 10,000 and 11,000 feet in a vicinity of the coal mines. These are of the semi-plastic variety and contain sulphur. The veins, with low sulphur content, are mined for the manufacture of brick. This material is hauled over the company's railroad to the plant and stored in piles where it is allowed to weather. The warm tropical sunshine of the day followed by freezing temperature at night causes the material to weather rapidly and the iron oxides and sulphides present are dissociated and driven off in a short time. The material used for brick has the following analysis:

SiO_2	57.60
Al_2O_3	26.88
Fe_2O_3	0.40
CaO	1.24
MgO	0.14
Loss	13.74

This clay is put into the wet pans direct and grog added in the form of crushed burned bats. After the desired plasticity has been obtained the mud is wheeled to moulding tables where nine-inch straights and the nine-inch series are moulded. The brick are put in the dryer for a short time and then repressed. Shapes are avoided whenever possible since this material is unsuitable for their manufacture. Circular bench setting with a four-inch space between benches proved to be the most successful method with the class of labor available since by using other methods the men neglected to leave sufficient draft space for proper heat distribution. Coal is used during the first stages of the burn but to obtain the finishing temperature of cone 5 oil is used. The available coal is a very low grade and suitable only for finishing common brick.

The brick produced from this clay are light brown in color with a fairly porous structure. They undergo but little volume change at medium temperatures and are well adapted for roaster linings, hearths and furnaces where a first class fire brick is not required.

Silica Brick.—The quartzite used for brick manufacture is grayish white in color and consists of medium sized grains of silica cemented tightly together by a silica matrix. These deposits are located at an altitude of 15,000 feet and about six miles from the railroad.

Contracts are let to the natives for the mining and transportation of this material to the plant. The rock is broken into lumps not exceeding six inches in diameter and packed in sacks of about 100 pounds each. Llamas are used for carrying these to the plant and one sack constitutes a load for an animal. These animals are very sensitive to the load which they will carry and it is claimed that if the burden exceeds one hundred pounds very much that they will kneel and refuse to move until the load is lightened. The quartzite unloaded at the plant cost about $2.75 per ton.

An average analysis is as follows:

SiO_2	96.96
Al_2O_3	1.12
Fe_2O_3	0.80
CaO	1.02
MgO	0.10

The quartzite must be sorted and washed before being used in brick manufacture since the contractors do not always reject the inferior grades. Low grade rock is set aside to be ground for locomotive sand. The selected material is broken down in a jaw crusher and then crushed through rolls. From here it is passed over a quarter-inch mesh screen and the fines are placed in wet pans for further grinding. Preliminary crushing and screening is necessary since the pans are of light structure and not suitable for heavy grinding. The batch is moistened and given a short grind before the addition of lime. Lime varying from 1.5 to 2 per cent of the weight of the quartzite is mixed in troughs and added in the form of a slip. The grinding is continued until the desired fineness is obtained. Shapes for reverberatory furnaces and nine-inch brick are moulded with no difficulty.

The lime used is burned at the plant since any quantity of limestone high in calcium carbonate and low in magnesia content is available in the surrounding country.

The same method of setting, as used with the fire brick, is followed and for burning coal and oil is used. The brick are burned to cone 16 and this heat held for 36 hours before closing. They have been unable to secure higher finishing temperatures for silica brick in these kilns since they were designed originally for burning common brick. At this altitude it is nec-

essary to increase flue sections about $33^1/_3$ per cent in order to gain sufficient draft for proper fuel consumption.

The first practices employed on this plant were the old "rule of thumb" methods introduced by men who had learned them after years of hard experience. They served their purpose for the time being but during the past few years the company has recognized the value and necessity of applying the most modern methods for producing the best ware with the materials available. A new plant is being constructed, under the guidance of a technically trained man, which will contain all modern machinery and mechanical equipment necessary for the production of first class refractories.

AMERICAN REFRACTORIES CO.
BALTIMORE, MD.

CERAMIC ABSTRACTS

Compiled by the

AMERICAN CERAMIC SOCIETY

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[1] The abbreviation (*C. A.*) at the end of an abstract indicates that the abstract was secured from the Editor of *Chemical Abstracts* by coöperative agreement.

General and Miscellaneous

1. Silica gel. ED. *Quarry & Surveyors' & Contractors' Jour.*, **27,** 44(1922).—The hydrous silicic acid known as silica gel has properties which may be useful in various industrial processes. Among these it has been proposed to use this subs. in the sulphuric acid industry for the purpose of abstracting small quantities of sulphur dioxide from gas mixts. containing as little as $^1/_2\%$ of SiO_2. This property of silica is due to what is called adsorption. The hydrated silica is dried, washed and partially dehydrated, producing a porous solid which possesses remarkable powers of adsorbing certain gases and is also capable of being metalized by platinum salts, whereby catalytic properties are acquired. There seems to be a distinct future for silica gel.

O. P. R. OGILVIE

2. The preservation of stone. NOEL HEATON. *Quarry & Surveyors' & Contractors' Jour.*, **27,** 56–61(1922).—This article gives preventive and preservative treatments, summarizing as follows: (1) New work can be rendered to a certain extent more resistant to decay by treatment with fluorsilicates, provided the strength of soln. and method of application is adjusted to suit the stone used. (2) No preservative treatment will be effective on faulty- or face-bedded stones. (3) Constructional methods of reducing decay (prevention of damp, effective carrying away of storm water, etc.) are more important than preservative treatment. (4) For outside work on old buildings no preservative at present known serves to preserve decayed stone for more than a limited period. The most economical treatment is dressing with soft soap and alum, renewed every few years. (5) In interiors, where the stone has been corroded by sulphur compds. baryta treatment is, in many cases, beneficial, but it should only be used with restraint and under careful supervision, and should be followed by distempering. (6) Preservative treatment should only be employed where it is certain that it can, at the worst, do no harm. For this reason, articles of unknown compn. should be avoided, and only materials used, the action of which is well understood. Progress toward the goal can only be obtained by constant exchange of experience and study of results.

O. P. R. OGILVIE

3. A scientific method of quarrying slate. ED. DELCOURT. *Quarry & Surveyors' & Contractors' Jour.*, **27,** 52–55(1922).—Mr. Delcourt describes at length the system which has been adopted with very satisfactory results, but has never been applied and is very little known outside the quarries supervised by himself. These quarries are worked by the Société Industrielle des Pyrenées, Labassére, Dept. des Hautes Pyrenées. The method is based upon the use of wire saws for quarrying slate; and after more than two years' experience at the quarries in question, the technical and economic results have exceeded all expectations. Figures and diagrams are given. O. P. R. OGILVIE

4. X-ray tests for stone. ED. *Quarry & Surveyors' & Contractors' Jour.*, **27,** 167(1922).—In Germany attention is being given to the examn. of building materials by means of X-rays. Twelve kinds of clay were examd. and various structures were observed in the X-ray diagrams, giving clear indications as to the uniformity and arrangement of the clay subs. The most conspicuous advantages of the X-ray method as compared with other testing processes are its cheapness and rapidity as well as the ease with which it can be used without any elaborate or difficult prepn., independently of any chem. analysis or the use of transparent microscopic sections, on large samples as well as on small amounts of material. Other kinds of building material showed interesting variations in permeability to X-rays, the following being arranged in the order of increasing transparency: Concrete mortar, granite, limestone, basalt, bricks, Horitz granite, Dutch bricks (clinkers), porphyry, gypsum, sandstone. In the case of concrete, a layer only 3 mm. thick of the concrete was found to afford excellent protection against X-rays.

O. P. R. OGILVIE

5. Italian non-metallic industries. ANON. *Chem. Trade Jour. & Chem. Eng.*, **71**, 12(1922).—The Genoa correspondent for this jour. under title of "Notes on the Italian Chemical Industry" gives a résumé of Italy's imports for 1921, which show a very decided increase over 1920 for the non-metallic industries. O. P. R. OGILVIE

6. Industrial and structural minerals. ANON. *Min. & Eng. Record*, **26**, 253–254 (1922).—A comprehensive survey of the growth in production during this year is given in this article. A special rotary furnace, invented and patented by Messrs. Thompson and Oliver has been used in the treating of magnesite at the Pacific Roofing Co.'s plant on Industrial Island and has done excellent work. Lime, silica, feldspar and talc are among the other minerals reviewed. Reference is also made to all the well-known producers of brick and refractories, cement, gypsum, sand and gravel with details of progress. O. P. R. OGILVIE

7. Cold production of water resistant material. ANON. *Keram. Rundschau*, **30**, 280(1922).—The compn. is as follows: 375 parts flint, 51 parts limestone, 8 parts calcined clay, 3 parts calcined feldspar and 28 parts water glass. The first four ingredients are mixed dry and then the water glass is added after which it is immediately pressed and dried. H. G. S.

8. Informational needs in science and technology. CHAS. L. REESE. *J. Ind. Eng. Chem.*, **14**, 364–8(1922).—The great need and value of coördinated, available information are discussed with a broad point of view and the efforts and plans of the Natl. Research Council in its Research Information Service towards the fulfillment of this need are described. E. J. C. (*C. A.*)

9. The factor of safety in research. A. F. SHULL. *Science*, **55**, 497–505(1922).—An address. E. J. C. (*C. A.*)

10. Electroösmosis. PAUL BARY. *Chimie et industrie*, **7**, 640–50(1922).—A review, with bibliography, of the applications of electroösmosis to industrial processes. Also in *Chem. Trade J.*, **70**, 625–7(1922). A. P.-C. (*C. A.*)

11. A comparison between stationary and mechanical producers. A. L. CULBERTSON. *Nat. Glass Budget*, **38**, No. 3, 22–6(1922).—A detailed account of the Chapman floating agitator. The m. p. of the ash of gas coals is usually within the limits 1900–2600°F. Corresponding to these temps. the blast temp. necessary to prevent clinkering in the producer varies from 148° to 108°F. J. B. PATCH (*C. A.*)

12. The pulverization of fuels. A. B. HELBIG. *Feuerungstechnik*, **10**, 114–9, 140–3(1922).—After giving the principles controlling the powdering of fuel, H. classifies the different kinds of machinery used for the purpose and describes and illustrates a typical machine of each kind. ERNEST W. THIELE (*C. A.*)

13. Improved low-temperature by-product recovery gas-producer process. POWER GAS CORPORATION. *Iron Coal Trades Rev.*, **104**, 576(1922).—The Mond gas-producer has been modified so as to combine the principle of low-temp. carbonization with the original Mond gas process. The process is one of complete gasification in which the volatile matter of the coal is converted into liquid products according to low-temp. methods, and the residual fuel entirely converted into producer gas. The transmission of heat to the raw coal is achieved in a gradual but effective and rapid manner by the use of the sensible heat contained in the hot producer gas evolved in the lower part of the producer without the intervention of retort walls. There are produced per ton of fuel about 115,000–120,000 cu. ft. of producer gas of 178 B. t. u. analyzing CO_2 8.3, CO 21.0, H_2 20.5, CH_4 4.9, N_2 45.3%, 15 to 24 gal. of low-temp. tars, and 90 lbs. of $(NH_4)_2SO_4$. The steam required in the process is about 1 lb. per lb. of coal gasified, the whole of which is decomposed. Air and steam superheaters are not required. Installation and maintenance costs are lower than for the original type of plant.
J. L. W. (*C. A.*)

14. Instruction of students in the use of technical literature; an unexploited phase of engineering education. E. H. McClelland. *Eng. Education*, **12**, 407–20(1922). E. J. C. (*C. A.*)

15. Relation of employer and employee as regards ownership of patents. Maurice Block. *Chem. Age* (N. Y.), **30**, 201–2(1922). E. J. C. (*C. A.*)

16. Current chemical patents and patent problems. Lloyd Van Doren. *Chem. Age* (N. Y.), **30**, 235–8(1922); cf. *C. A.* **16**, 1822. E. J. C. (*C. A.*)

17. Influence of patent law on the evolution of research. H. E. Potts. *Chem. Age* (London), **6**, 726–7(1922). E. J. C. (*C. A.*)

BOOKS

18. Jahr- und Adressbuch der Bau- und keramischen industrie. (Industrie der Steine und Erden, Glas und Porzellan.) 1920–1. Edited by R. Hanel. Vienna: Compassverlag. 328 pp. M 32. Reviewed in *Tonind. Z.*, **46**, 481(1922). (*C. A.*)

19. Taschenbuch für Keramiker. Berlin: Verlag Keramische Rundschau, G. m. b. H. 206 pp. Reviewed in *Z. angew. Chem.*, **35**, 211(1922). (*C. A.*)

PATENTS

20. Gas producer. H. G. Johnston. U. S. 1,412,118, Apr. 11. (*C. A.*)

21. Gas producer. W. B. Chapman. U. S. 1,412,921, Apr. 18. (*C. A.*)

22. Gas producer. F. M. E. Blass. U. S. 1,414,109, Apr. 25. (*C. A.*)

23. Device for selective absorption from gas in transmission lines. F. F. Uehling. U. S. 1,412,790, Apr. 11. (*C. A.*)

Apparatus and Instruments

24. The construction of electric steel furnaces. M. Guédras. *Technique moderne*, **13**, 497–501(1921).—A discussion of the construction of elec. steel furnaces and of the importance of interposing non-magnetic parts in the shell thereby preventing the presence of a closed magnetic circuit and elimination of induction at Foucault's currents, and of the necessity of adopting a spherical formula to obtain as complete a utilization of the energy as possible. A. P.-C. (*C. A.*)

25. Wood-Harry cleaner and concentrator. Anon. *Chem. Eng. Mining Rev.*, **14**, 142–3(1922).—A new type of concentrator for cleaning floated sulfide or other ores from gang and also for the primary flotation of sulfide ores has been developed at Mt. Lyell. The app. may also be used for cleaning fine coal or graphite. The concentrator consists of a series of atomizing wheels set in cells below the bottom of the box of the machine and driven at variable speeds by high-pressure water jets. Air is led into the cells so as to impinge on the blades of the wheels. Air bubbles generated by the wheels join those already in the primary froth or feed to the machine and so change the nature of the froth that it no longer holds the gang in suspension. Louis Jordan (*C. A.*)

26. Air bubble viscosimeter. V. R. Abrams, J. T. Kavanagh and Chas. H. Osmond. *Chem. Met. Eng.*, **25**, 665–6(1921).—A glass tube, 21 cm. long and from 5.2 to 5.3 mm. in internal diam., with 2 lines etched on it 10 cm. apart near the middle of the tube, is sealed off at one end. The tube is filled with oil and closed with a tight-fitting glass cap which encloses a vol. of air which will fill 1.7 cm. of the tube when inverted. The time required for the bubble to pass between the 2 marks is proportional to the viscosity in Saybolt seconds and the "factor" may be obtained by calibration with a sample of known viscosity. Variations should not be over 1% for oils having a viscosity between 80 and 475 sec. Saybolt. The use of diams. other than those given or of an unrestrained bubble is impracticable and, therefore, water can not be used for calibration. The caution is given that when oils are re-run repeatedly, the viscosity may change considerably. Eugene C. Bingham (*C. A.*)

27. A microscopic arrangement for the examination of opaque crystals. M. FRANÇOIS AND CH. LORMAND. *Bull. soc. chim.*, **29,** 366–74(1921).—No contrivance has previously been devized for rendering visible microscopically very small opaque or deeply colored crystals in all their details without deformation, halo or false colors. Various methods led to the development of 2. Lateral illumination by an incandescent Pt wire permitted perfect vision with objectives 7 and 8 but was discarded because of frequent fusion of Pt and heating of both the crystals and the objective. The method adopted consists of (1) an ordinary microscope with its objectives fitted on their lower face with a Ag concave mirror pierced by a hole; (2) an incandescent light placed in the microscopic axis with its rays rendered parallel to the axis by a lens; and (3) a glass slide with an opaque disk on which rest the crystals protected from the light passing from beneath. The curvature of the mirror must be such that the reflected light converges on the object, and consequently each objective must have its own mirror. The width of the mirror should be equal to or less than its radius of curvature. The opaque disks are made of various colors depending on the crystals, and vary from 0.75 to 3.0 mm. in order to cover the field of any size of objective. The source of illumination can be a 2–3 v. lamp, 1–2 cm. diam. set in an eye-piece so that the lens renders the rays parallel. Directions are given for the mech. construction of the complete contrivance. Crystals of Fe, Cr and Ni silicides, Hg_2NI, $Hg_7H_2NI_4$, HgS, etc., have been photographed by this method with remarkable results. C. C. DAVIS (*C. A.*)

Chemistry, Physics and Geology

28. Measuring kiln gases. ANON. *Brick Pottery Tr. Jour.*, **30,** 132(1922).—The meas. of the vol. of gases passing through the flues of a kiln or up a chimney is by no means an easy task, as these gases are charged with both moisture and dust, and can not be passed through a "pitot" tube. For many reasons sufficiently accurate results may be obtained by inserting a damper having a sharp orifice at its center, this orifice being 1″ or more in diam., according to the size of the flue. When the gas passes through such an orifice the vel. is greatly increased, some of the original pressure being converted into vel. pressure, while the static pressure of the gas which has passed through the orifice is lower than the original static pressure. The quantity (Q) of gas flowing through the pipe in cu. ft. per sec., is found by the following equation:

$$Q = 403\frac{CATh}{PD}$$

C is the coef. of flow (usually about 0.95–0.99), A is the area of the orifice, h the differential pressure (in in. of water) of the gas on each side of the orifice, P is the absolute pressure of the gas in in. of mercury, T is the absolute temp. in degrees C and D is the density of the gases referred to air at the same temp. There are difficulties connected with the meas. of the temp. and pressure of the gas, but when these are overcome the method is fairly accurate. H. G. SCHURECHT

29. Immense deposits of magnesite in southern Nevada. ANON. *Clayworker*, **78,** 29(1922).—A massive deposit of magnesite of unusual character has been found by the U. S. Geol. Surv. in Clark Co., Nev., in the valley of Muddy River a few miles from St. Thomas. This material has for some time been mistaken for kaolin but it was recently found to be a highly magnesian sedimentary bed. The material is porcelain white, fine-grained and massive, is remarkably free from foreign material, and has a structureless appearance and a conchoidal fracture. It is not as hard as typical magnesite. In places the deposit is 200 ft. thick. H. G. SCHURECHT

30. Colloidal clay production. ST. AUSTEL. *Quarry & Surveyors' & Contractors' Jour.*, **27,** 228(1922).—The possibilities of colloidal clay production continues to be

discussed as a means of extending the demand of china clay for new uses, but as yet the work is in the experimental stage. Colloidal clay results from the subjection of ordinary china clay to chemical treatment carried on in specially constructed tanks, between the washing and drying processes now applicable to ordinary china clay production. Colloidal clay may be said to be the essence of china clay, all impurities and deleterious matter having been eliminated or neutralized by the chemical treatment. It is claimed that the value of the clay thus purified is enhanced by pounds per ton at comparatively small cost. O. P. R. OGILVIE

31. Mineral resources of Jugoslavia. ANON. *Nature*, **110**, 34(1922).—This issue of *Nature*, in reviewing the report, "Geology and Mineral Resources of the Serb-Croat-Slovene State," states "Among the other minerals that have been or are being worked may be named bauxite, meerschaum and rock salt." O. P. R. OGILVIE

32. Mica in India. ANON. *Imp. Inst. Bull.*, **19**(1921).—In J. C. Brown's "Notes on Mica" (Bulletin, Indian Ind. & Lab., No. 15, 1921) he gives much information as to the industrial uses of mica, its specifications and standards, and brief notes on characteristics of the mineral and its production in India. Methods of trimming, grading, sizing, and splitting mica are described, as well as mica preparations, substitutes, prices and sources of supply, concluding with a summary of the outlook for Indian mica. O. P. R. OGILVIE

33. Some simplified formulas for excess air. JOHANN AGTHE. *Feuerungstechnik*, **10**, 113–4(1922).—Refers to the combustion of gases only.
ERNEST W. THIELE (*C. A.*)

34. Kaolin and kaolinized granite in the district between Strobel and Saarau, Silesia, and their formation. L. VON ZUR MÜHLEN. *Z. prakt. Geol.*, **1921**, 56–61.—Descriptions of several deposits are given, with analyses. The kaolin passes gradually into unaltered granite, and was formed by the action on the granite of the waters of Tertiary swamps, whose place is now occupied by lignite which was deposited in them.
E. F. H. (*C. A.*)

35. The volumetric determination of titanium dioxide in bauxite. H. J. WINCH AND V. L. CHAND-RATREYA. *Chem. News*, **124**, 231–2(1922).—Fuse 0.3 g. of the sample with 3 g. $KHSO_4$, dissolve the melt in hot dil. HCl and reduce the Fe^{+++} to Fe^{++} and the Ti^{++++} to Ti^{+++} by treatment with 0.15 g. of powdered Sn. Add an excess of $HgCl_2$ to remove the excess Sn and titrate Fe + Ti with standard $K_2Cr_2O_7$ soln. With another sample carry out the same procedure but in place of metallic Sn use $SnCl_2$ soln. as reducer, stopping as soon as the yellow $FeCl_3$ is reduced, thus detg. Fe alone.
W. T. H. (*C. A.*)

36. An apparatus for the rapid measurement of surface tension. R. G. GREEN. *J. Bact.*, **7**, 367–70(1922).—An app. called the surface tension balance is described for the rapid measurement of surface tension by the drop-weight method. It consists of a dropping pipet, a delicate torsion balance, and an adjustable scale upon which the surface tension is read directly in dynes per cm. JOHN T. MYERS (*C. A.*)

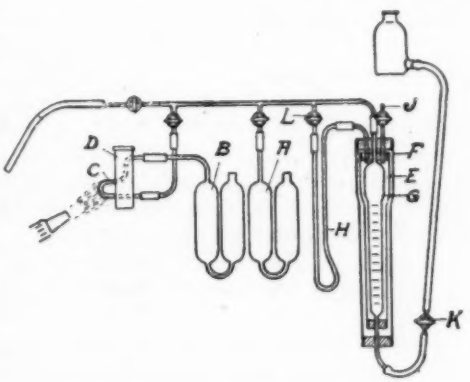
37. New stalagmometer or guttameter. F. ESCHBAUM. *Ber. pharm. Ges.*, **31**, 211–9(1921).—In estimating the surface tension of liquids by the drop method, the rate of outflow must not exceed 14 to 16 drops per min., a condition usually attained by providing the instrument with a sufficient length of capillary tubing. The same result is more readily secured by the following device. The upper end of the stalagmometer or guttameter consists of a glass stopcock having an opening on one side, the barrel of which has grooves running parallel to its length and communicating with each other at both top and bottom. A portion of the surface remains smooth so that the stopcock may be completely closed. On turning the barrel, the air in passing to the top of the liquid can be directed through any desired length of capillary, thus regulating the

outflow of liquid accurately. The paper includes tables for calcg. guttameter estns. to stalagmometer measurements, and for normalizing any guttameter readings. In corrections for temp., every increase of 1° in the atm. temp. the drop wt. (guttameter) decreases by 0.25%, while the drop number (stalagmometer) increases by 0.25%.
W. O. E. (*C. A.*)

38. The origin of gumbotil. G. F. KAY AND J. N. PEARCE. *J. Geol.*, **28,** 89–125 (1920).—The aim of this paper has been to show by field and lab. evidence that the gumbotils on Nebraskan, Kansan, and Illinoisan glacial tills are the results of chem. weathering of the drift and furnish good criteria for differentiating the older drifts. It is recognized that wind action, freezing and thawing, burrowing of animals and slope wash have also contributed to their formation. W. F. HUNT (*C. A.*)

39. Some colloidal properties of Pleistocene clays and their bearing on the chemical theory of the formation of gumbotil. J. N. PEARCE AND L. B. MILLER. *J. Phys. Chem.*, **26,** 1–24(1922).—The authors discuss the geological and chem. evidence in support of the theory of Kay and Pearce (preceding abstract). This assumes that, following the laying down of each original drift, a long period elapsed during which chem. weathering and leaching took place; that the upper layers are the residual left by those processes. After a time diastrophic movements occurred, and erosion then developed the topography existing at the ends of the interglacial periods. L. W. RIGGS (*C. A.*)

40. Modified Orsat apparatus for flue-gas analysis. O. I. HANSEN. *Ingeniören*, **30,** 467–8(1921); *Chimie et industrie*, **7,** 494–5(1922).—In the course of flue-gas analyses H. found that most of the errors of the Orsat app. are due to temp. variations caused by the construction of the app. In the modified app. devized by him, the graduated buret *G* is surrounded by an air jacket *E* (contg. a little distd. water in the bottom), surrounded in turn by a water jacket *F*. *E* is connected with the manometer tube *H*; *J* is a tap which is used to equalize the pressure in *E* (to avoid having too great a correction for temp. and barometric pressure) and which remains closed during the analysis. The shape of the jackets *E* and *F* is similar to that of *G* instead of having a uniform diam. as in the regular Orsat.



A. P.-C. (*C. A.*)

41. Practical interpretation of automatically recorded volumetric percentages of carbon dioxide in flue gases. W. E. APPLEBY. *Chem. Eng. Mining Rev.*, **14,** 156–60 (1922).—A flue-gas delator (alinement chart) is developed and illustrated. By the alinement of the values representing the vol. of CO_2 in the flue gas as read from an automatic CO_2 recorder and the difference in temp. between the atmosphere and the exit gas, the heat value wasted is read directly. LOUIS JORDAN (*C. A.*)

42. New conceptions of electrolytes. I. The degree of dissociation of acetic acid in water and in salt solutions. ERLING SCHREINER. *Z. anorg. allgem. Chem.*, **115,** 181–202(1921).—A theoretical paper in which formulas are derived for correcting the dissoc. const., as ordinarily detd. from cond. measurements, for the viscosity of the soln., inter-ionic force, and the activity of the water, that is, the hydration of the H-ion. The cond. of AcOH as detd. by different observers is thus corrected at 25° over the

range of diln. from 0.0005 to 2.6 normal. The law of mass action is shown to hold up to the highest concn. From potential measurements at 18° and 25° of AcOH solns. contg. NaOAc or other salts, the activity of the acetate ion and the dissoc. const. of AcOH have been calcd. Such measurements do not, as has been generally supposed, det. the H-ion concn., but the activity of the H-ions, which is associated only with the non-hydrated ions. The dissoc. consts. of AcOH calcd. thus agree well with those calcd. from the cond. measurements. Taking the activity const. of the H-ion as 0.2, that of the acetate ion is the same in NaOAc soln. and 0.3 in Na and K chloride solns. **II. The introduction of a catalysis coefficient in hydrogen-ion catalysis.** *Ibid.*, **116,** 102–16.—In catalytic reactions such as the hydrolysis of esters or the inversion of sucrose by acids, assuming complete dissoc. and that only the H-ions are active, the reaction velocity should be proportional to the concn. Actually, however, the catalytic effect at higher concns. is greater, and a similar accelerating effect is produced by the addition of neutral salts. It is shown that, by the introduction of a catalysis coeff., f_k, this extra catalytic effect can be accounted for. The new coeff. is found to be the reciprocal of the cond.-viscosity coeff., f_μ, which is the ordinary cond. coeff. corrected for the viscosity of the electrolyte. The ratio v/C, where v is the reaction velocity and C the acid concn., thus corrected to vf_μ/C, gives a very good const. in the hydrolysis of acetates by HCl alone and in presence of neutral salts, in the inversion of sucrose, and in the keto ⟶ enol acetone transformation. The degree of dissoc. of weaker acids, such as dichloracetic or cyanoacetic acid, can be calcd. from catalysis measurements, and the results agree very closely with those calcd. from cond. measurements. J. C. S. (*C. A.*)

43. Notes on white chlorites. E. V. Shannon and E. T. Wherry. *J. Wash. Acad. Sci.*, **12,** 239–41(1922).—New analyses of white chlorites, called colerainite, sheridanite, etc., gave:

	1	2	3
SiO_2	28.10	36.70	27.78
Al_2O_3	26.20	10.38	24.30
Fe_2O_3	1.66	1.22	0.35
FeO	none	trace	1.43
CaO	trace	0.86	trace
MnO	trace	trace	none
MgO	30.36	36.44	32.71
H_2O+	14.00	13.80	13.01
H_2O-	0.56	1.06	0.06
sum	100.88	100.46	99.64
α	1.562	1.555	1.576
β	1.562	1.560	1.576
γ	1.576	1.560	1.589
2E	0°	30°	small
sign	+	—	+

1. Brinton's Quarry, Pa. 2. Nottingham, Pa. 3. Wyoming. White chlorite from Sylmar, Pa., showed the forms: 001, 010, 110, 112, 011, 043, 111, 132, 101, 134. The Pa. chlorites were formed by the action of Mg-bearing waters on albite-pegmatite.

Edw. F. Holden (*C. A.*)

44. The mechanism of the dehydration of crystalline aluminium hydroxide and of the adsorption of water by the resulting alumina. L. H. Milligan. *J. Phys. Chem.*, **26,** 247–55(1922).—Cryst. $Al(OH)_3$ prepd. by the Bayer process does not lose wt. below 145° at atm. pressure. Above this temp. decompn. sets in with loss of water until at 200° the trihydrate is completely decomposed. The porous Al_2O_3 still retains 8% water which is given up slowly as the temp. is increased, indicating that it is held by adsorption.

Intermediate hydrates between $Al(OH)_3$ and Al_2O_3 do not exist. On rehydrating the ignited Al_2O_3 in moist air at room temp. it takes up water, the amt. taken up being greater the lower the temp. of ignition. The curves obtained on drying these samples show that the cryst. $Al(OH)_3$ is not formed again, but the water taken up is adsorbed. X-ray examn. (by Hull's method) of the materials shows that the cryst. $Al(OH)_3$ is identical with the mineral gibbsite, and that the ignited Al_2O_3 has an entirely diff. structure. The X-ray pattern of the Al_2O_3 does not change as it adsorbs water.

F. L. BROWNE (*C. A.*)

45. A centrifugal method for preparing colloidal ferric hydroxide, aluminium hydroxide, and silicic acid. RICHARD BRADFIELD. *J. Am. Chem. Soc.*, **44**, 965–74 (1922).—Hydrosols of hydrous Fe_2O_3, Al_2O_3, and SiO_2 of unusually high purity can be prepd. by pptg. the oxides by addn. of NH_4OH to the corresponding chlorides or HCl to Na silicate, resp., and very thoroughly washing the ppts. by decantation until they begin to become colloidal. They are then suspended in water and passed through a Sharples Supercentrifuge operating at 32,500 r.p.m. The deposit is repeatedly suspended in water and centrifuged. The lower half of the contents of the bowl is then stirred up in water, giving a hydrosol, Sol A, the upper half similarly giving Sol B. The liquid discharged from the centrifuge on the fourth and subsequent washings is Sol C. Analysis of one of the Fe_2O_3 sols showed 396 g. equiv. Fe_2O_3 per g. equiv. Cl. The SiO_2 sols are free from Cl^-. The sols are very stable; even Sol A, which contains the largest particles, gave no sepn. on 20 min. centrifuging at 2000 r.p.m. On boiling the sols may be reduced almost to sirupy consistency without coagulating. When $Al_2(SO_4)_3$ is pptd. by NH_4OH the ppt. can be peptized by this method, showing that SO_4^{--} does not ppt. the sol irreversibly as heretofore supposed. SiO_2 sol free from electrolytes has $p_H = 6.5$

F. L. BROWNE (*C. A.*)

PATENTS

46. Treating clay. W. FELDENHEIMER and W. W. PLOWMAN. Brit. 175,050, Nov. 8, 1920. Clay is deflocculated with the aid of an alkali resinate or its equiv., such as a soln. of a resin acid in one or more alkalies, the preferred reagent being a soln. of common resin in caustic alkali, alkali silicate, or alkali carbonate, or a mixt. of caustic alkali and alkali silicate. The reagent may be applied before or after passing the suspension over mica drags, and also for the deflocculation of an already purified clay. Subsequent pptn. of the clay from the suspension may be effected as described in 121,191. (Cf. *Jour. Amer. Ceram. Soc.*, **4**, 495(1921).) (*C. A.*)

47. Zinc oxide. A. PEARSON. Brit. 176,588, Jan. 17, 1921. Crude ZnO contg. colored oxides of Cd and Pb is mixed with a small quantity of $ZnSO_4$ or H_2SO_4, and calcined in a muffle at a temp. not exceeding 878°, preferably 720–820°, so as to convert the Cd and Pb into white compds. The $ZnSO_4$ added should be finely divided. (*C. A.*)

Refractories and Furnaces

48. Research is tool which will improve refractories. W. A. HULL. *Brick Clay Record*, **60**, 544–5(1922).—H. states that user and consumer should know refractories; that tridymite improves silica brick; that furnace designs should be given more attention; that chrome Fe ore is a good refractory; and that special refractory oxides and silcates should be investigated.

H. G. SCHURECHT

49. Electric furnace iron and steel. Intermittent and alternating operations. W. E. CAHILL. *Trans. Am. Electrochem. Soc.*, **41**, preprint, April (1922); *Iron Age*, **109**, 1277–8(1922).—Elec. furnace Fe castings have been made at Treadwell, Alaska, since 1918, where it has been found cheaper than possible with a cupola. The av. power consumption for 25 consecutive heats of iron and steel with 2-voltage control shows

a saving of 75 kw.-hr. per ton of Fe and 42 kw.-hr. per ton of steel. Cast iron was made with 784 kw.-hr. per ton, and steel with 893 kw.-hr. per ton. Intermittent operation is most severe on electrodes and roof. A good spout is of prime importance so that the furnace will drain. Cast gray iron of a uniformly fine-grained structure and low S, free from occluded gases is obtained. The removal of S depends upon the length of time the metal is held under a carbide slag. W. E. RUDER (*C. A.*)

50. Operation of the electric blast furnace. SEIGLE. *Rev. metal.*, **19,** 86–9(1922).—A discussion of the effect of rapid changes in temp. upon the compn. of the gas in the mouth of the furnace and the quality of the melt due to the resulting equil. between coke and ore, with special reference to the method of charging and the descent of material in the furnace. W. A. MUDGE (*C. A.*)

51. Cost of heat-treated parts reduced to a minimum by electric furnace. C. L. IPSEN. *Elec. World*, **79,** 1125–6(1922).—Detailed cost figures and comparative figures for oil furnace are given. C. G. F. (*C. A.*)

52. An adaptable electric steel company. S. G. KOON. *Iron Age*, **109,** 1196–1202 (1922).—A description of the melting, heat-treating and forging equipment of the Sizer Steel Co.'s plants at Buffalo and Syracuse. Two 12-ton Heroult furnaces, each making 4 heats per day, receive power from Niagara. All other heating is done with pulverized coal. Crank shafts, connecting rods, die blocks, stern and rudder frames, balls, rod and bars are produced. Illus. of equipment and layout are given. W. E. R. (*C. A.*)

53. Electric tool steel melting practice. W. J. GREEN AND S. S. GREEN. *Iron Age*, **109,** 999–1001(1922); cf. *C. A.* **16,** 23, 686.—The major aspects of (*a*) acid *vs.* basic bottom, (*b*) liquid *vs.* cold charge, and (*c*) double *vs.* single voltage are discussed. The basic bottom is preferred, not on account of refining the charge, but because of its ability to carry a strongly reducing slag, atm. and general melting practice. Cold charges are preferred, as open-hearth metal, impoverished by its melting conditions, can not be fully rejuvenated by ordinary elec. furnace methods. Crucible quality may only be obtained by melting high-grade cold charges. Double voltage of 115–125 high to 75–85 low is satisfactory. Higher voltages are at present satisfactory only for medium or cheaper products. A single voltage of 95 is a satisfactory all-round pressure, in life of refractory, output and quality of product. W. E. RUDER (*C. A.*)

54. The Fiat electric furnace. ANON. *Engineering*, **113,** 421–2(1922).—About 50 Italian firms now have elec. furnace equipment. There are about 100 small furnaces of about 1 ton which work only a few mos. during the year. In northern Italy there are now 22 15-ton Heroult furnaces and 10 of 5–8 ton capacity. The Fiat furnace has been in constant operation for the last 5 yrs. There are now four 20-ton and 12 smaller (3–6 ton) furnaces in operation at the Fiat plants. The furnace is cylindrical in shape, 3-phase type, with the hearth slightly conductive and connected to ground. A characteristic feature is the "economizer" or electrode holder which completely encloses the furnace roof. This is a water-cooled cylinder, fitted with insulating rings to guide the electrode, and prevents their wasting. The design provides for ease of access for maintenance. The sides of the electrodes remain parallel and carry greater current down inside the furnace, thus reducing the working time. The electrode consumption is 6.3 lb. per ton of steel. The av. power required is 650 kw. hrs. per ton. Roof and linings last about 150 heats, and clamps have not needed renewal in 5 years. It has been possible to reach 9 heats per 24 hrs. starting from a cold charge.
W. E. RUDER (*C. A.*)

55. Electric furnace melting. H. NEEDHAM. *Chem. Met. Eng.*, **26,** 871(1922).—The selection of the correct elec. system is the secret of the com. success of an elec. furnace. The elec. furnace depends not upon any cleansing action so much as upon the

absence of contaminating impurities. Modern furnaces are fitted with tight doors, electrode economizers and flame muffling devices, which makes them very highly efficient. The use of small or large amts. of Al is purely a question of skilled metallurgy.

W. E. R. (*C. A.*)

56. Melts aluminium in electric furnace. H. E. DILLER. *Foundry*, **50**, 345–51 (1922).—A description of an elec. installation and a comparison of results with crucible and elec. furnaces. The furnace consists of a large steel shell on trunnions and swung by a hand wheel. The body and cover are lined with insulating material and fire-clay brick. Two electrodes are connected with resistance formed of small particles of C held in a carborundum trough, which extends completely around the furnace at the height indicated by the electrodes. The heat is reflected to the roof and down upon the metal. The metal is charged through a door in the rear and is rabbled during the melting operation through a rear door. The bath is fluxed with cryolite. The hand ladles used are preheated. It requires 728 kw. to melt 1 ton (909 kg.); this high figure is due to the heat of fusion of Al. The principal expense in the crucible process lies in the crucibles and in the elec. furnace. The expense is due to high installation and current costs. The latter costs are not increasing as rapidly as fuel costs and melt losses are about $^1/_4$ those of the crucible process. Other advantages of the elec. furnace include: absence of fume and smoke, little lining repair, lower heat radiation and better working conditions. *Heats of fusion* in B. t. u. are given as: Al, 139; Zn, 58; Sn, 25.

W. H. BOYNTON (*C. A.*)

57. The melting of cast iron in the Booth rotating electric furnace. H. M. WILLIAMS AND T. B. TERRY. *Trans. Am. Electrochem. Soc.*, **41**, preprint, Apr. (1922).—Results of research with a small (250 lb.) elec. furnace are described. 750 heats have been made, and the furnace is now making 15 heats per week. Satisfactory castings have been made from boiler-plate, ferro-silicon and C; malleable from borings and steel; and iron alloys of various kinds. Refining by slagging is not possible with this type of furnace.

W. E. RUDER (*C. A.*)

58. Electric furnace melting. W. H. KEEN. *Chem. Met. Eng.*, **26**, 869–70(1922).—Elec. furnace processes should be compared with the open-hearth and not the crucible process, though the product may resemble that of the latter. For this reason an open-hearth melter is usually better adapted to elec. furnace operation than a crucible melter. It is quite possible to make high-grade steel from poor scrap in the elec. furnace, but it is usually not advisable from a cost viewpoint. Al should not be used to correct improper working, but a little should be added, to insure complete deoxidation.

W. E. RUDER (*C. A.*)

59. An explanatory note on heat insulating materials. MAX JAKOB. *Arch. Warmewirtschaft*, **3**, 23–6(1922).—An explanatory discussion of an article by Hencky and Cammerer, *Mitt. Forschungsheim für Warmeschutz*, Nos. 1 and 2. Contrary to H. and C. the only comparable method of expressing value of an insulating material is its heat transmission coeff. Tables are given showing that the fall in temp. or the total amt. of heat lost per hour depends on so many variables that they can not be used as a comparison of insulating materials. The paper contains a number of references to articles on heat-insulating materials.

W. L. BADGER (*C. A.*)

60. (Blast furnace) lining failures caused by zinc. P. O. MENKE. *Iron Trade Rev.*, **70**, 1409–10(1922); cf. *Ceram. Abs.*, **1**, 181(1922).—Investigations of several disintegrated blast furnace linings showed the presence of varying amts. from 0.1 to 40% of ZnO absorbed in the body of the brick. It is often present in the ores and limestones from certain regions. It is assumed that it had combined with the alumina in the brick. Its effect, which is accumulative, is to expand and break up the bond. Water-cooling above the mantle seems to accelerate the action. By using a heavy shell, if

necessary above 1-in. thick, and removing the water-cooling above the mantle, the trouble can be reduced to a min. J. L. WILEY (*C. A.*)

61. Cast iron as produced in the electric furnace and some of its problems. G. K. ELLIOTT. *Trans. Am. Electrochem. Soc.*, **41**, preprint (1922); *Iron Age*, **109**, 1225–6.—The history of the development of the elec. furnace for the prepn. of cast Fe is outlined. The refining on a basic bottom of cupola-melted metal is the field of widest possibilities for the elec. furnace for cast Fe. Ability to refine in addition to melting and increased power to superheat are 2 desirable characteristics lacking in the cupola but outstanding in the elec. furnace. Elimination of S is the most striking reaction in the basic elec. furnace. Anomalous results have been reported as to the effects of S on irons. Low S may be simply an indication that the iron has passed through a strong refining treatment and better quality in such a case may be due to elimination of little known impurities, as O or N. One of the moot questions of cast Fe is whether or not Fe oxide can exist in molten cast Fe in the presence of the usual amt. of C, Si, and Mn and, if it is present, whether its influence is harmful or beneficial. The question of O in cast Fe, as well as that of N and other gaseous elements, must remain unsettled until satisfactory analytical methods are available. The superheating possible in the elec. furnace is of advantage in producing fluidity with any compn. of Fe. There is evidence that elimination of CO and CO_2 in cast Fe has a retarding effect on the pptn. of graphite. This factor may contribute to the increased strength and soundness of elec.-furnace cast Fe. LOUIS JORDAN (*C. A.*)

62. Chromite in 1921. EDWARD SAMPSON. U. S. Geol. Survey, *Mineral Resources of U. S., 1921*, Pt. I, 15–17 (Preprint No. 3, publ. May 15, 1922). E. J. C. (*C. A.*)

63. Recovery of radiated heat from a rotary kiln or drier. ANON. *Chem. Met. Eng.*, **26**, 846(1922).—The kiln is to be surrounded by an insulated housing. Air is to be drawn through the annular space and thus preheated before being used in firing the kiln. The radiation from an uncovered kiln may be as high as 1000 B. t. u. per sq. ft. per hr. Insulation within the kiln is not practical because of the high temp. of the refractories which would result. W. L. BADGER (*C. A.*)

64. Electromagnetic motions in electric furnaces. CARL HERRING. *Trans. Am. Electrochem. Soc.*, **41**, preprint (1922); cf. *C. A.*, **15**, 1857; *J. Franklin Inst.*, **192**, 599(1921).—It is the purpose of the present paper to show how the new law proposed in the former paper may be applied in practice to the production of possible forces for performing desired useful operations, like circulating, stirring, transferring, etc., in elec. furnaces. Guides are given to aid in detg. whether such motions can probably be produced by the current. The former restrictions to only one such motion-producing force were not justified, and many others formerly not accepted are possible. D. MACRAE (*C. A.*)

PATENTS

65. Refractory compositions. BUFFALO REFRACTORY CORPORATION. Brit. 176,436, Nov. 2, 1920. A refractory compn. comprizes Si carbide, flake or cryst. graphite, a flux, and a carbonizing binder, such as tar or molasses. As fluxes, clay, salts, such as borax, metallic or non-metallic oxides, or sulfides may be used. The mixt. is molded in the usual manner and baked at about 1000°. Suitable proportions of the ingredients are 68 pts. of Si carbide, 25 pts. of graphite, and 7 pts. of flux, or of flux and binder. The compn. is suitable for making heat-resisting articles such as crucibles, fire bricks, retorts, muffles, furnace cores, tubes, combustion boats, pyrometer tubes, furnace linings, and heat-resisting cements. (*C. A.*)

66. Refractory compositions. BUFFALO REFRACTORY CORPORATION. Brit. 176,437, Nov. 2, 1920. A refractory compn. for making heat-resisting articles, such as

crucibles, comprises a refractory elec.-furnace product such as fused alumina or silica, flake or cryst. graphite, a flux, and a carbonizing binder such as tar or molasses. As fluxes, clay, salts such as borax, metallic or non-metallic oxides, or sulfides may be used. The mixt. is molded in the usual manner and baked at about 1000°. Suitable proportions of the ingredients are 60 pts. of the elec.-furnace product, 20 pts. of graphite, 12 pts. of binder, and 8 pts. of flux. Cf. preceding pat. (*C. A.*)

67. Preserving electric-furnace linings. H. C. SICARD. U. S. 1,416,584, May 16. A lining contg. Ti oxide is used in smelting mixts. contg. Ti ores and other ores such as Fe oxide or Fe and C. (*C. A.*)

68. Refractory composition. H. H. BUCKMAN and G. A. PRITCHARD. U. S. 1,412,916, Apr. 18. A material adapted for making retorts, muffles or crucibles is formed of zircon and a refractory clay. Cf. *Ceram. Abs.*, **1**, 68(1922). (*C. A.*)

Abrasives

69. Abrasives. ANON. *Min. & Eng. Record*, **26**, 253(1922).—This year abrasives have been produced in B. C. for the first time. A shipment of quartz has been made from the Drum Lummon Mine to Victoria to be used in the manufacture of sand paper. O. P. R. OGILVIE

70. Garnet. RAYMOND B. LADOO. U. S. Bur. of Mines, *Repts. of Investigations*, No. **2347**, 16 pp.(1922).—This paper gives a general description of garnets, their geological occurrence, localities (N. Y., N. H., N. C., Conn., Pa., Ga., Va., Spain, Labrador), statistics as to production (from 1910–18, U. S. production was four to six thousand tons/yr., the value increased from 113 to 248 thousand dollars, N. Y. being the largest producer), methods of mining and milling tests, uses (abrasives) and a bibliography. EDW. F. HOLDEN (*C. A.*)

PATENTS

71. Metallic carbides. S. GOLDSTEIN. Brit. 175,638, Feb. 16, 1922. Artificial stones for making drilling and turning tools and wire-drawing dies are produced by mixing powd. W, Mo, or like difficultly fusible metal with diamond dust, and heating the mixt. in a closed mold in an elec. arc or resistance furnace. The product is a carbide which may contain excess C in the form of diamond particles, particularly in the center of the mass. Other metals such as Fe and Ti may be added to the mixt. before heating. (*C. A.*)

72. Artificial corundum. H. A. RICHMOND and R. MACDONALD, JR. U. S. 1,413,785, Apr. 25. Impure Al_2O_3 is melted, a portion of the Si and Fe oxides is reduced by C in an elec. furnace (without materially reducing the Ti oxide which is present to not more than 0.6%) and the mass is allowed to cool. (*C. A.*)

Stoneware, Whiteware and Porcelain

73. The influence of fuels containing sulfur on lead glazes. ANON. *Keram. Rundschau*, **30**, 280(1922).—Sulfureous gases only affect the glazes when the fumes come in contact with the ware. If the draft is good this does not occur in a muffle or semi-muffle kiln, but when the draft is sluggish these fumes permeate through the muffle and combine with the glazes causing a dull gloss. When using a semi-muffle kiln the ware should be protected by means of slabs, so placed as to prevent the gases from coming in direct contact with the ware. Firing with a reducing atm. after the glaze has commenced to melt will prevent dull glazes. H. G. SCHURECHT

74. Artificial teeth. ANON. *Keram. Rundschau*, **30**, 280(1922).—The bodies are rich in feldspar and are fired to cones 5–7. TiO_2 and Fe_2O_3 are added for color. H. G. S.

75. Collophane, a much neglected mineral. A. F. ROGERS. *Am. J. Sci.*, **3**, 269–76 (1922).—Collophane is amorphous Ca "carbophosphate," usually massive, sometimes oölitic, sp. gr. 2.6 to 2.9, varying with its porosity and compn.; the hardness varies from 3 to 5, and n from 1.57 to 1.63. Collophane is the main constituent of *phosphate rock*. Analyses of 4 foreign specimens are recorded, also one from Crawford Mts., Utah, which gave: CaO 50.97, MgO 0.22, Fe_2O_3 + Al_2O_3 0.76, Na_2O 2.00, K_2O 0.47, SiO_2 0.30, P_2O_5 36.35, CO_2 1.72, F_2 0.40, SO_4 2.98, H_2O 1.05, insol. 1.82, sum 99.04%. The mineral may be regarded as a solid soln. of CaF_2, $CaSO_4$, $CaCO_3$ and CaO in $Ca_3(PO_4)_2$. Like most other amorphous minerals it is of colloidal origin and contains an indefinite amt. of water. Formula: $3Ca_3(PO_4)_2.nCa(CO_3, F_2, SO_4, O).(H_2O)_x$, where n is an indefinite number varying from 1 to 2. The carbonate radical usually predominates over the other minor constituents. L. W. RIGGS (*C. A.*)

BOOK

76. Meissner Porzellan. DOENGES, WILLY. 2nd Ed. Dresden: Wolfgang Jess. 236 pp. M 75, bound M 95. Reviewed in *Tonind. Z.*, **45**, 1257(1921). (*C. A.*)

PATENTS

77. Filter press with a rotary filter. R. D. LUCAS. U. S. 1,415,461, May 9. (*C. A.*)

78. Potter's clay. R. L. CAWOOD. U. S. 1,414,254, Apr. 25. A potter's clay having the properties of true kaolin is prepd. by subjecting a natural mixt. of partially and wholly kaolinized feldspar to comminution in H_2O and removing mica and excess H_2O. (*C. A.*)

Art and Design

79. Black porcelain glazes. ANON. *Keram. Rundschau*, **30**, 280(1922).—Two kgs. of coloring oxide are used to 50 kgs. of glaze. The following coloring oxides are usually employed: U_3O_8, CoO and Mn_2O_3. H. G. S.

80. A comparative study of methods used for the measurement of color. T. MARTIN LOWRY AND L. P. MCHATTON. *J. Oil Colour Chemists' Assoc.*, **4**, 189–204 (1921). F. A. WERTZ (*C. A.*)

81. Color measurement. HEINRICH TRILLICH. *Farben-Ztg.*, **27**, 1721–3, 1794–8, 1874–6, 2017–22(1922).—A criticism of Ostwald's system of color designation (*C. A.*, **14**, 492) and a suggested modification of his color circle. F. A. WERTZ (*C. A.*)

82. Theory and practise in color measuring and recording. A. E. BAWTREE. *J. Oil Colour Chemists' Assoc.*, **4**, 165–88(1921).—A discussion of the system of designating colors as described by Lawrence (*C. A.*, **13**, 1643) and their measurement according to this system with the Bawtree colorimeter (*C. A.*, **15**, 2). F. A. WERTZ (*C. A.*)

83. Color circles. W. H. THOMAS. *Textile Colorist*, **44**, 241–2(1922).—Describes a circle system of shading which shows the shade produced by mixing any 2 colors, and its comparative brightness. CHAS E. MULLIN (*C. A.*)

Heavy Clay Products

84. Durability of cement drain tile and concrete in alkali soils: Third progress report (1919–20). G. M. WILLIAMS. *Bur. Standards, Tech. Papers*, No. **214**.—The third progress report on the investigation of the durability of cement drain tile and concrete exposed to alkali soils and waters gives an account of the condition in 1919 and 1920 of exptl. drains laid in western alkali districts in 1913, and of large concrete blocks similarly exposed in 1915. Both drain tile and concrete blocks were made up in sufficient quantity and variety to be representative of all qualities, and were installed in typical alkali sections of the arid belt from New Mexico to Montana. With reference to drain

tile the following tentative conclusions have been drawn: (1) The use of cement drain tile in soils where sulphates occur in considerable quantities is hazardous. In certain localities the best quality of tile disintegrated within six years. (2) Porous or permeable tile, made from lean or dry mixts., are subject to disintegration in sulphate waters of relatively low concn. (3) Disintegration of mortar or concrete in sulphate waters may be due in part to physical forces arising from crystn. of salts in the pores, but it is primarily due to chem. attack upon the cement. (4) In the best quality of tile the outer skin may sometimes remain apparently unaffected, at the same time allowing the alkali water to pass through and attack the mass underneath. (5) In tile of given quality exposed to sulphate waters, the disintegrating effect seems to vary with the concn. (6) Tile made by hand or with the packer-head type of machine, and of sufficiently dry consistency to permit immediate removal of the molds, are less resistant to alkali action than tile of a wetter consistency which requires their retention in the molds for a period of hours. (7) Tile cured with steam seem to be no more resistant to alkali attack than those cured by systematic sprinkling. Tar and cement grout coatings were not effective in protecting the tile. (8) If cement drain tile are to be used in soils or waters containing more than 0.1% of sulphates, careful consideration should be given to sub-surface conditions, the quality of tile to be used, etc. (9) Quality of cement drain tile can best be measured by permeability tests. There appears to be little definite relation between permeability and the related factors of porosity, absorption, and density. With regard to concrete the following tentative conclusions have been drawn: (1) Materials of good quality and proper workmanship are of great importance in the fabrication of concrete exposed to alkali soils and waters. (2) Surface action on concrete blocks of good quality after 1 year's exposure has in most cases been progressive. (3) The extent and rapidity of disintegration depends upon concentration of soluble sulphates. (4) Disintegration of concrete blocks containing reinforcing rods has in some cases been aided by corrosion of the rods and consequent splitting of the concrete. (5) Concrete structures exposed to alkali waters should be given all possible protection by drainage. (6) Concrete of the best quality will disintegrate if exposed to sufficiently high concns. of alkali, such as were encountered in some of the locations where the test blocks were installed. (7) So far as the tests indicate, the resistance to alkali action of mass concrete, made of the same aggregates and exposed to the same concns., varies with the cement content or richness of mix. This again seems to indicate that strength and permeability, rather than absorption, are the governing factors in determining the quality and durability of concrete under alkali exposure. This paper carries two appendixes, one containing a summary of the absorption tests on samples of all types of drain tile used in the investigation, and the other a discussion of the occurrence of sol. salts in the soil and their action on cement and concrete. H. F. S.

85. Manufacture of sewer pipe. ANON. *Keram. Rundschau*, **30**, 301(1922).—The firing of sewer pipe can be done most economically in coupled kilns, whereby the hot gases pass through at least 3 kilns and the heat from the cooling kilns is utilized in the heating up the newly set ware. In this manner the heat is more thoroughly utilized and about 50% of the fuel is saved over that used by the periodic system.

H. G. SCHURECHT

86. Increasing kiln volume without more kilns. ANON. *Brick and Clay Record*, **61**, 102–5(1922).—The Minter flue system is described. This system permits continuous burning in periodic kilns, saves fuel and speeds up burning. This system will work on practically any plant with moderate changes. H. G. SCHURECHT

87. The dielectric anomalies of silica glass. A. JAQUEROD AND H. MUGELI. *Arch. sci. phys. nat.*, **4**, 10–26(1922).—An introductory sketch of theories of dielectrics. Exptl. results are promised later. E. D. WILLIAMSON (*C. A.*)

88. Clay pipe pronounced equal to cast iron pipe. S. E. DIBBLE. *Brick and Clay Record*, **61,** 34(1922).—D. established (1) that a proper bituminous compound can be used efficiently in jointing a clay pipe; (2) that joints made in this manner developed will stand any pressure that the pipe is capable of standing, without leaking; (3) that a pipe line so jointed can be thrown out of alignment without causing a leakage at the joints, and (4) that leaks due to poor workmanship can be repaired easily and quickly.

H. G. SCHURECHT

89. Manganese for improving quality. ANON. *Brick and Clay Record*, **61,** 32–33(1922).—By the use of Mn., better color can often be produced in brick; light burn and buff brick can be made into beautiful French gray shades; remarkable and unusual speckled effects can be produced; red burning clay can be made to produce the very popular brown shades; and better colors can often be produced in drain tile and hollow-tile which burn to unsightly colors.

H. G. SCHURECHT

Glass

90. Unbreakable glass. ANON. *So. African Jour. of Ind.*, **5,** 237(1922).—At one of the oldest glass factories in Bohemia, after many years of experiment, a glass has been produced, which is claimed to be absolutely unbreakable. Receptacles made from the material can be thrown about, made red hot, and then put into cold water, without breaking. Hammers can be made from it and it is difficult to cut it even with a diamond. It is important to note, however, that this invention can only be placed on a commercial basis when a special kind of sand is available in large quantities. At the present time it exists only in the neighborhood of Dresden and in small quantities. The original founder of the factory was an ordinary glass blower, who rose to fame by his production of chemical glass.

O. P. R. OGILVIE

91. Glasses colored with copper oxide. ALBERT GRANGER. *Le Verre*, **2,** 73–4 (1922).—A blue glass may be obtained from the following:

$$\left.\begin{matrix}2.5\\3.0\\3.5\end{matrix}\right\} \; SiO_2 \; \left\{\begin{matrix}0.05\ CuO\\0.25\ CaO\\0.70\ Na_2O \text{ or } K_2O.\end{matrix}\right.$$

Substitution of 0.25 CaO, BaO, ZnO, or PbO in the 3.5 SiO_2 formula does not cause any change in the color. In the 3.0 SiO_2 glass, 0.25 MgO developed a poor blue. Lowering the alk. and increasing the lime gives a blue-green as in 2.5 SiO_2, 0.05 CuO, 0.45 CaO, and 0.50 Na_2O or K_2O. Increase in CuO to 0.10 causes this glass to become green, further additions of CuO causing the glass to darken. In the following a green effect is noticed as the lime increases:

$$3.5\ SiO_2 \; \left\{\begin{matrix}0.05\text{–}0.05\text{–}0.05\ CuO\\0.25\text{–}0.45\text{–}0.55\ CaO\\0.70\text{–}0.50\text{–}0.40\ Na_2O\end{matrix}\right.$$

A blue-green glass is obtained from an increase in the CuO:

$$3.0\ SiO_2 \; \left\{\begin{matrix}0.10\text{–}0.10\text{–}0.17\ CuO\\0.20\text{–}0.40\text{–}0.41\ CaO\\0.70\text{–}0.50\text{–}0.42\ Na_2O\end{matrix}\right.$$

More acid glasses will also have a blue-green color:

$$3.5\ SiO_2 \; \left\{\begin{matrix}0.05\text{–}0.10\text{–}0.25\text{–}0.25\ CuO\\0.45\text{–}0.65\text{–}0.50\text{–}0.25\ CaO\\0.50\text{–}0.25\text{–}0.25\text{–}0.50\ Na_2O \text{ or } K_2O\end{matrix}\right.$$

In the glass 3.5 SiO_2, 0.05 CuO, 0.70 CaO, 0.25 Na_2O, where the lime is much in excess, the copper is pptd. by touching the hot melt with a cold body. *Effect of alumina.*

Addition of 0.1 Al_2O_3 to 3.5 SiO_2, 0.05 CuO, 0.25 CaO, 0.70 Na_2O showed no effect. *Effect of boric anhydride.* The following glasses have a very rich peacock blue tint:

$$3.0\ SiO_2 \left\{ \begin{array}{l} 0.05\text{–}0.10\ CuO \\ 0.25\text{–}0.20\ CaO \end{array} \right. \\ 0.5\ B_2O_3 \left\{ 0.70\text{–}0.70\ Na_2O \right.$$

On increasing the B_2O_3 content, the glasses are much darkened:

$$2.5\ SiO_2 \left\{ \begin{array}{l} 0.05\text{–}0.15\ CuO \\ 0.20\text{–}0.15\ CaO \end{array} \right. \\ 1.0\ B_2O_3 \left\{ 0.70\text{–}0.70\ Na_2O \right.$$

Besides the deepened color, these glasses appear green-black by reflection. The simultaneous addition of B_2O_3 and Al_2O_3 seems to give more transparency to the glass than with the B_2O_3 alone, as in:

$$\left. \begin{array}{l} 2.5\ SiO_2 \\ 1.0\ B_2O_3 \end{array} \right\} 0.25\ Al_2O_3 \left\{ \begin{array}{l} 0.15\ CuO \\ 0.15\ CaO \\ 0.70\ Na_2O \end{array} \right.$$

and

$$\left. \begin{array}{l} 3.0\ SiO_2 \\ 0.5\ B_2O_3 \end{array} \right\} 0.10\ Al_2O_3 \left\{ \begin{array}{l} 0.05\ CuO \\ 0.25\ CaO \\ 0\ 70\ Na_2O. \end{array} \right.$$

Effect of ferric oxide. The addition of 0.027 Fe_2O_3 to 2.5 SiO_2, 0.11 CuO, 0.36 CaO, 0.53 Na_2O gave a true green, whereas the base glass did not. LOUIS NAVIAS

92. The manufacture of reflecting surfaces. K. GUNDLACH. *Naturwissenschaften*, **10**, 117–9(1922).—A discussion of a recent symposium ("*A Discussion of the Making of Reflecting Surfaces held on Nov. 26, 1920 at the Imperial College of Science and Technology, So. Kensington*," Fleetway Press. Holborn). The subjects are treated historically, scientifically and technically and include (1) a survey of the bibliography on metallic deposition on glass; (2) a bibliography of the important papers on the construction and nature of reflecting surfaces; (3) the formaldehyde process of silvering; (4) workshop notes on silvering; (5) silvering of glass reflectors by chem. deposition; (6) silvering of a large reflector; (7) silvering of quartz and glass-fibers; (8) mirrors used for reflecting heat radiation; (9) deposition of metals by cathodic sputtering *in vacuo;* (10) production of mirrors by cathodic bombardment; (11) Pt reflecting surfaces prepd. by the burning-in process; (12) mirrors for use in optical instruments under industrial conditions and (13) a photometric method of measuring the reflecting power of mirrors. C. C. DAVIS (*C. A.*)

93. Glass-lined tanks. G. F. KROHA. *Ungerer's Bull.*, **3**, 21–2(1922).—The gradual development of the industry, the construction of the various forms and the final coating with glass are described in considerable detail. W. O. E. (*C. A.*)

94. New recuperative pot furnace. W. R. CULBERTSON. *Glass Worker*, **41**, No. 34, 11, 29(1922).—The Chapman Stein recuperator applied to pot furnaces gives more accurate temp. control. Records from such a 14-pot furnace (each pot holding a batch of 2400 lbs.) which has been in operation in this country for nearly a year also show that from 10–15 more pots per week are obtained from this furnace with about 35% less fuel than from an adjacent regenerative furnace of the same size. J. B. P. (*C. A.*)

95. Effect of the rays from radium, X-rays, and ultraviolet rays on glass. J. R. CLARKE. *J. Soc. Glass Technology*, **5**, 155–65(1921).—A series of soda-lime glasses of the same compn., except that some contained Se, some Co oxide, and others no admixture, has been exposed to the action of α-, β- and γ-rays, β- and γ- rays, γ-rays, X-rays, and ultraviolet rays, resp. All glasses contg. Se or Co oxide were colored brown by β-rays, the depth of coloration corresponding with the range of the β-particles in the glasses. The intensity of coloration was greatest at the surface, decreased toward the interior, and in-

creased with increasing Se or Co oxide content. As the radiation was prolonged, the intensity increased to a max., which depended on the percentage of coloring agent, and then remained const. The pure soda-lime glass was only affected by α-rays, being faintly colored on the surface only. None of the glasses was affected by X-rays, γ-rays, or ultraviolet rays. All the glasses fluoresced in Ra Em, but a fatigue effect was observed at about the same time as the attainment of max. intensity of coloration. The coloration of glasses is regarded as due to the formation of colloidal particles in the glass. The presence of such particles is explained as being due to the action of α- or β-rays on ions already present in the glasses. The fluorescence is held to be due to mechanical bombardment of the glass mols. by the rays. J. C. S. (*C. A.*)

96. An autoclave test for the grading of chemical glassware. W. L. BAILLIE AND F. E. WILSON. *J. Soc. Chem. Ind.*, **41**, 45–56T(1922).—Contains much exptl. work. Important. Can not be abstracted. G. E. BARTON (*C. A.*)

PATENTS

97. Glass. W. C. TAYLOR. U. S. 1,414,715, May 2. A flesh-colored glass of high ultra-violet absorption and good visible transmission is formed with a content of 3–6% CeO_2 and 0.2% MnO_2, together with SiO_2, K_2O, Na_2O and CaO. Cf. *Ceram. Abs.*, **1**, 216(1922). (*C. A.*)

98. Compound glass sheets. J. COX. Brit. 175,044, Nov. 6, 1920. In making compd. glass sheets, the surfaces are treated with a soln. composed of gum mastic, amyl acetate, pyroxylin or collodion, and ricinol oil, dissolved in abs. alc., and superposed sheets are subjected to pressure at a temp. which allows superfluous liquid to escape. When cool, the edges are treated with linseed oil, and the sheets are again heated and pressed; and the edges of the finished sheets are finally sealed with a soln. of shellac in methylated spirit. (*C. A.*)

99. Glass. H. T. BELLAMY and B. T. SWEELY. U. S. 1,415,980, May 16. A non-electrolytic glass suitable for use as a binder for high-resistance compns. is formed of silicates and borates of Ca and Ba. (*C. A.*)

100. Glass. TITANIUM PIGMENT CO., INC. Brit. 176,430, Oct. 29, 1920. TiO_2, is introduced into glass batches in the ratio of not less than 25% of the whole. *E. g.*, silica 69 parts by wt., borax 10, Na_2CO_3 29, CaO 7, TiO_2 45. (*C. A.*)

Cement, Lime and Plaster

101. Analysis of gypsum in cements—quick method. C. BERTIN. *Rev. Mat. Constr. Trav. Pub.*, **154**, 133(1922).—*Ordinary method.* 1–2 gm. of cement are dissolved in hydrochloric acid, and the silica removed after evapn. to dryness, by filtering the remoistened residue. The sulphur trioxide is then pptd. as barium sulphate, which is filtered off, ignited and weighed. Time, about 3 hrs. *Quick method.* 1 gm. of cement is boiled in 50–60 cc. of distilled water, containing 2 gm. of ammonium chloride for 8–10 mins. Pass the soln. through an ordinary filter, acidify the filtrate (*a*) with hydrochloric acid, and bring to a boil, add a pinch of barium chloride crystals, continue boiling for 5 mins., then let stand $^1/_2$ hr. Filter off the barium sulphate, wash, ignite and weigh. Time, about 1 hr. The ammonium chloride increases the soly. of the gypsum in the water soln., the gypsum passing into the filtrate (*a*). As a small quantity of lime is also dissolved, it is necessary to convert it to the chloride before adding the barium salt. The results of this method compare favorably with those obtained by the longer methods. LOUIS NAVIAS

102. Plant of the Mozambique Portland Cement Co., Ltd., at Lourenco Marques. ANON. *Jour. Chem. Met. & Min. Soc. of So. Africa*, **22**, 203(1922).—The Portland cement factory of the Mozambique Cement Co. will have an output of 700 tons of Port-

land cement per week. The method of manuf. is upon the wet process. The raw materials are brought to the factory by barge, where they will be unloaded upon a jetty and transferred to the factory. The limestone is fed to jaw crushers, 1,000 mm. by 500 mm., after which it passes through crushing rolls. This reduces the limestone to approx. walnut size. It is then elevated into a hopper over a compd. ball and tube mill, 11 m. long and 1.8 m. in diameter. The clay, when delivered to the factory, is first dealt with in a wash-mill, after which it is pumped into the compound ball and tube mill and ground with the limestone. Water is introduced into the grinding mill, and the limestone and clay are ground together in the wet state (about 40% of water) to a fineness of about 10% on 180-mesh sieve. The "slurry," as it is termed, coming from the compd. ball and tube mill is elevated into one of three mixers, where it is thoroughly mixed and proportioned. One mixer is of sufficient capacity to enable the kiln to run over the week-end without refilling. The slurry transport and agitation is carried out in a special manner. Hitherto, slurry has been pumped by plunger or centrifugal pumps, and agitated mechanically. In this factory, however, completely new methods are introduced, and the slurry is elevated by means of pressers and is agitated in the tank by means of blasts of compressed air. When found to be of correct proportions for calcining, the mixing tank is sealed and is used for the supply of the kiln. The kiln itself is 56 m. long and 2,800 to 2,300 mm. in diameter. The plates in the firing zone are approx. $^7/_8$ in. in thickness, and the kiln is furnished with four cast-steel rollers and a cast-iron rim for the drive. The cooler is attached to the kiln in prolongation. This attachment permits of several advantages, notably, only one motor to drive, instead of two where the cooler is separate; much lower foundations; absence of stairs, gangways, etc., and perfect accessibility and easy attendance. Furthermore, no movable kiln head is required; and a considerable saving through the utilization of heat radiated from the material passing through the cooling section is effected. Coal is supplied to the kiln in the following manner: When delivered to the factory by trucks run in on the company's siding, the coal is first crushed and thoroughly dried in a rotary drier. It is then passed through a small compound ball and tube mill, 8 m. in length and 1.4 m. in diameter. It is then elevated into a storage hopper, from which it is wormed into the coal feed pipe through which a continuous blast of air passes by means of a high-pressure fan. The clinker coming from the cooler is taken on a shaker conveyor to the boot of an elevator, which elevates on to another conveyor running over the whole length of the clinker store. Sufficient storage has been allowed for four weeks' out-put at the rate of 1,400 T. per week (the factory is so designed as to permit of duplication in the near future). The clinker is reclaimed by a conveyor running underneath the clinker store house, and after the gypsum has been added is elevated over a compound ball and tube mill for clinker grinding. The cement is ground to a fineness of 8–10 per cent on 180-mesh sieve, and is wormed and elevated into the cement store, where automatic sack-packing machines have been provided. (*So. African Eng.*, February, 1922 (A. K.).) O. P. R. OGILVIE

103. Tests on mortars and concrete immersed in sea water for 15 years. E. CANDOLT. *Rev. Mat. Constr. Trav. Pub.*, **153**, 105–6(1922).—Results of test pieces made at Haïphong, Indo-China. Large blocks were cemented onto the rocks, so that they were completely covered at high tide and uncovered at low tide by the sea water for 15 yrs. Cement N° 1, used for sea construction work had the following properties:—% chem. comp., SiO_2 22.20, Al_2O_3 6.85, Fe_2O_3 2.00, CaO 66.05, MgO 0.25, SO_3 0.50, ignition loss 2.15, apparent d. 1.228, time of set 4 hours, tensile strength in Kgs. per sq. cm. on pure cement, after 7 days, 34.0, 28 days 45.0, $2^1/_2$ years 57.7, on 1:3 plastic mortar, after 7 days 12.0, 28 days 15.0, $2^1/_2$ years 34.0. Cement N° 3 (not intended for sea construction work), % chem. compn., SiO_2 21.65, Al_2O_3 6.90, Fe_2O_3 1.95, CaO 64.75, MgO 0.30, SO_3 0.60. Ignition loss 3.85, apparent d. 1.182, time of set 3 hrs. 10 mins.,

tensile strength, on pure cement, after 7 days 37.9, 28 days 50.5, $2^1/_2$ yrs. 59.2, on 1:3 plastic mortar, after 7 days 19.2, 28 days 26.5, $2^1/_2$ yrs. 32.3. Compression tests were made on cubes of 10 cm. side, cut from the large pieces after 15 years' immersion. Results given are for the average of 6 tests for each mixt., in Kg. per sq. cm. Mortars. To 1 cubic meter of sand, 250 Kg. Cement N° 1, 213.33 Kg. per sq. cm. 450 Kg. Cement N° 1, 323.5, 650 Kg. Cement N° 1, 504.16, 450 Kg. Cement N° 3, 480.8, 650 Kg. Cement N° 3, 697.5, 1,000 Kg. Cement N° 3, 710.83. Concrete. 450 Kg. Cement N° 3, 1 cubic meter sand, 1.5 cubic meters pebbles, 336.66, 1.000 Kg. Cement N° 1, 1 cubic meter sand, 2 cubic meters pebbles, 492.5.

LOUIS NAVIAS

BOOK REVIEWS

A valuable addition has been made to the library of ceramic publications. This is the "1922 Clay Products Cyclopedia," published by Industrial Publications, Inc., 407 South Dearborn Street, Chicago, Ill. The book consists of two main parts, the first information on definitions and statistics, and the second, catalog pages of the manufacturers of equipment. The definitions cover 117 pages and describe 752 processes, materials and pieces of equipment. These definitions are amply illustrated. The statistical section covers 75 pages, arranged and indexed for instantaneous reference. This section is valuable in order to save the time of an executive in searching for the necessary data.

An original index is one called the Departmental Index of Plant Equipment. In this index are listed the numbers of all items that are used in or concern each department. The numbers of the items refer to the definitions. In this way the reader can easily find all related topics, and determine through the definitions the one best adapted to the use he has in mind.

The catalog section contains informative data regarding the equipment and materials manufactured by the different firms supplying the industry.

The value of the Cyclopedia lies in the fact that it combines in one book information which the clay products manufacturer would otherwise be compelled to search for in various catalogs, reference and technical books.

This book is published by the same organization that publishes *Brick and Clay Record*. The combination gives to the clay products manufacturer all possible information that he requires. The periodical treats of current topics, new developments, improvements, trade matters, and association and convention items. The Cyclopedia, being a year book, furnishes all necessary information for reference use bound in one volume.

This book is being received with great interest throughout the industry.

F. A. GUIGNON

Proposed Scientific Journal

The preliminary issue of the *Journal of Scientific Instruments* has been received and will prove of exceptional interest to the readers of this *Journal*. An introductory article in the *Journal* explains the importance of issuing a British Journal of this type but unless sufficient subscribers are obtained the publication will be discontinued. The *Journal* is a monthly publication dealing with the principles, construction and use of instruments. The contents of the preliminary number together with the list of articles in prospect give promise that the *Journal* will occupy a position of importance among the scientific journals. Among the articles listed are the following: "The

Scheme for a Journal of Scientific Instruments" by E. H. Raynor; "Instruments and Apparatus in Relation to Progress in Physiology" by A. V. Hill; "The Use of a Reference Plate for the Micrometric Measurement of Astronomical Photographs" by Sir Frank Dyson; "The New Fundamental Bench Mark of the Ordnance Surveys" by Sir Charles Close; "The Optical Sonometer" by F. Twyman and J. H. Dowell; "Two Machines for Rapidly Weighing Loads of a Few Milligrams" by The Research Staff of the General Electric Co., Ltd., London; "Reid Control Indicator for Aeroplanes" by Dr. J. Robinson; "The Measurement of the Internal Diameters of Transparent Tubes" by John S. Anderson, and a number of others. Copious advertising in this issue has enabled the editor to obtain the best of paper and printing and the cuts are many and good. The *Journal* is published by the Institute of Physics, London, with E. H. Raynor as acting editor.

Official Personnel of Divisions 1922–23

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BULLETIN

of the

American Ceramic Society

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EDITORIALS

OUR TWENTY-FIFTH ANNIVERSARY CONVENTION

February 12–17 Is the Date and Pittsburgh Is the Place

It was a quarter of a century ago that a few ceramists decided to found a society for the purpose of advancing the ceramic arts and sciences. It was an ambitious proposition then, a little in advance of the industrial demands but results have proven that the pioneer ceramists had a true conception of the industrial needs. What a contrast there is today from twenty-five years ago in the attitude of the factory operators on questions of technical control and research! The charter members of the Society should be given credit for their foresight; for anticipating the demand and for actually being the first and the prompting factor in the development of a demand in the ceramic industries for technical control and research. During these twenty-five years there has been a positive change from resistance to the advances of technical men to a demand for them by the industries that actually exceeds the supply.

Being a natural sequence to the graduation of the first class from the Ohio State University Ceramic Department in 1897 the attention of the Society was most largely confined to promoting ceramic education. The fundamentals of what is recognized today as ceramic science and technology were known to very few. There had been no correlation of the large mass of practical knowledge such as we have today. There were no ceramic

• Glass Division Committee on Refractories. D. W. Ross, Chr., C. O. Grafton, A. S. Zopf, C. E. Fulton. | Fredk. Carder, Ira E. Sproat | W. C. Lindemann, H. F. Staley | H. W. Hess, J. W. Wright | Geo. A. Bole, Eben Rodgers | M. C. Gregory

departments in the Bureaus and there were only scattered attempts to apply the fundamental findings of the scientists to factory problems. Much that the students in the ceramic course under Professor Orton were discovering and publishing for the first time is today taken for proven facts, the basis on which to further research.

Twenty-five years ago the Society could be nothing other than an educational institution. All, the plant operators and the scientists alike, had a very great deal to learn through investigations and plant trials. The "researches" of those early days were crude as viewed from the present time. They could not be otherwise for there were no established limits and no directions. It was pioneering even in the outlining of the investigations.

The Ceramic Department organized by Professor Orton was the first effort in ceramic education in this country. There were opposition and prejudice to overcome in establishing the Department of Ceramics at Ohio State University and he did not receive a very general support when, with the other charter members, he organized this Society. The founding of these two pioneer institutions required the mose persistent promotion.

Contemporary with the latter day activities of this Society, the several schools in turn established ceramic departments and the Federal Bureaus began ceramic investigations. To all of these enterprises the Society gave encouragement, moral support and in some instances, political help. A proper tracing of the growth of the Society in industrial influence and as a factor in ceramic education involves a history of all agencies that have added to the total of ceramic knowledge closely associated as they all have been and mutually dependent.

None would be so blind to the facts as to assign credit for the present status of ceramic knowledge and technology to the American Ceramic Society. But all the collegiate and federal ceramic departments, scientific and technical organizations, the technical press and industrial laboratories in this country as well as in other lands have contributed to the fund of knowledge that has been collected during these past twenty-five years. Our sister ceramic societies in England, Germany and elsewhere have been large contributors with the American Ceramic Society, pioneer among them all, maintaining the aggressive lead and doing the larger share.

The celebration of this twenty-fifth anniversary will be more than the observance of the founding of the American Ceramic Society; it will be the commemoration of the first collaboration of industry with the colleges and other research agencies, applying science and scientific methods in the analysis of and adding to the vast fund of practical knowledge already at hand. That collegiate ceramic departments, federal agencies and other ceramic organizations were later organized and have grown in strength and service is a natural sequence. They have given substantial proof that this pioneer Society was founded for a needed purpose.

It seems strange, as we view those early days, that in the light of our present-day experiences ceramic industries did little more than to tolerate the advances made by the American Ceramic Society. In contrast to the indifference of the plant operators in the early years of the Society, the several Trade Associations today are supporting joint researches and a large number of individual plants are employing ceramic engineers and maintaining ceramic laboratories.

This Twenty-Fifth Anniversary Convention will be the occasion for doing more than to establish facts regarding the developments in ceramic technology during the past years; it will be the opportunity for looking squarely at present-day technical and scientific needs of the ceramic industries and for making plans for the collaboration of all on a much more comprehensive plan. In this manner the immediate future will find the ceramic manufacturers ready to meet the more strict specifications of the purchasing public and the ever-changing industrial needs.

The history of the last twenty-five years in ceramic technology and art will be set forth in the January number of this *Journal*. This will be a thorough "Looking Backward" or inventory of the many things acquired during the past twenty-five years. This will leave for the Convention a survey of the present day needs and "Looking Forward."

The Board of Trustees, all standing committees and especially the Divisional officers and committees are making plans that this Anniversary Convention may be occasion for a larger realization of the need for aggressive fostering of technical and scientific research and especially as joint enterprises by industrial associations with collegiate and federal research organizations, as well as by groups by themselves. This should indeed be a profitable event for the ceramic craft.

DISCUSSION[1] ON "USE OF FORCED DRAFT FOR TERRA COTTA KILNS"[2]

MR. HOTTINGER:—I am sure we have a new subject, one that has never been brought up in the Ceramic Society to my knowledge, *i. e.*, use of forced draft in firing except possibly on some brick kilns, but never in the terra cotta industry.

MR. RADCLIFFE:—Mr. Chairman, about five or six years ago I was doing some work for the Kellogg Brick Company at Peoria. They were making common brick and paving brick. In one of their yards they had considerable trouble in getting the brick hard at the bottom of the kiln so we decided to install a forced draft system on their kilns. We tried it out on one of them that was particularly bad. These kilns were not very well constructed, and had a lot of leaks in them.

They were not able to get more than about fifty per cent of No. 1 pavers, and that burned all the way from nine to fourteen days to finish off the kiln.

This system that Mr. Carruthers describes is known as the Boss system of firing, in respect to method of inducing draft. In the Boss system they put a sewer pipe around underground, and used about one and one-half, or two horsepower for a twenty-eight or thirty foot kiln.

We were able to improve conditions wonderfully. We were able to get No. 1 pavers in the bottom of the kiln and in the center, and we got no over-burning whatever on the top near the bag walls, or any part of the kiln. Previously they were getting over-burned pavers. Sometimes they had to go in with a sledge hammer to get them out. After this, even at the bag walls they got no overburning. They got a percentage increase of twenty to thirty per cent. In other words, they got around eighty per cent No. 1 pavers. They were able to burn the kilns off in six days instead of from nine to fourteen, and they were able to use just the ordinary screenings instead of using fairly good coal. At that time, screenings were worth about fifty cents a ton, while the coal, mine run, was selling at about two and a half a ton. We used screenings entirely for the burn, and of course, made a very considerable saving, and at the same time increased the output of No. 1's, and the brick did not stick together at all. The temperature was very uniform.

Before the forced draft was installed, the smoke and fire seemed to be coming out on all sides of the kiln. They puttied those places up, and thus improved the conditions. As it saved fuel, and brought up the percentage of No. 1 brick, they installed it on all of their kilns. And there you have it. They are using it now, finding it very successful.

I never tried them out on a terra cotta kiln, the reason being that we had a different type of kiln there, and I was afraid of the very point that

[1] Terra Cotta Division, St. Louis Meeting, Feb., 1922.

[2] Carruthers, *Jour. Amer. Ceram. Soc.*, **5**, 449(1922).

Mr. Carruthers brought out; that burning of slack in that type of kiln would clog it up, and would cut down the draft, and so might be dangerous.

However, with the updraft type of kiln, I do not believe it would give any trouble, and it seems to me that it ought to be a very good burning method.

A MEMBER:—May I ask about how many times an hour you have to bait the fire boxes?

J. L. CARRUTHERS:—The fireman makes a coaling round about every fifteen minutes, depending upon the stage of the burn. After firing, he makes several rounds adjusting the draft.

A MEMBER:—I wonder if the whole thing doesn't boil itself down simply into a proposition of getting the fireman to fire more often.

MR. KLINEFELTER:—You know our problem is that in the day time you can usually get your fireman to fire once an hour, and the night man takes it about every two hours and a half. If you could get a fireman to fire every fifteen minutes you could fire all slack coal right enough, but you can not get them to do it. Of course, I can see the advantage of a forced draft; he is forced to fire every 15 minutes.

MR. GATES:—We try to fire about 15 minutes to one-half hour, depending upon the stage of the burning. In the early stages we do not fire as often as we do at high temperatures.

We had a little experience along this same line. We tried the forced draft system of burning about a year and a half ago, but our experience is negative, for some reason we could not make it go.

I can give you all the different kinds of different and conflicting conditions that we ran into. We would burn twice as much coal, and not make any heat, or half as much coal and make a lot of heat.

We never could find out what made it go and what made it stop. The main condition that we had was that of having no grates. We used simply a closed ash pit, and blew the air into it through a funnel. Of course one big difficulty we had was with clinkers, but they didn't bother us generally until we got to the point where they started to fuse. Even on some burns, we didn't have very much difficulty with the clinkers, and so I am of the opinion that if you don't get everything just right, you will have a lot of difficulty with a forced draft system.

We had flames shooting out of the top of the kiln, and we had the stack red hot. We could get the outside of the kiln very hot but we couldn't get the inside of it very hot.

I think that the main part of that difficulty is due to the fact that we didn't get a sufficient amount of air in over the grates. You can regulate that air in through the grates, so you can practically have a producer gas. It would be possible to make this a fairly good grade of producing gas. We saw it one time. We tried that at one time when we were trying to

make heat. We increased our firing, and there was no flame in the stack but the gas came out of the stack and then burned. Our experience was absolutely negative.

MR. HILL:—I am not surprised that Mr. Gates got negative results, because it is my experience that firing is a matter of the kiln design. If a kiln is designed for the other type of firing, it may not necessarily be adaptable to this, because you are changing your conditions entirely.

MR. GATES:—I might say that I believe that the Denver plant is using both the up-draft and the down-draft kilns. I don't know why it didn't work. We fired it not only every fifteen minutes, but every five minutes as well.

MR. MCMICHAEL:—I have visited a lot of places where it is successfully employed.

A MEMBER:—I believe he attributes considerable of the success he had had with this system to these boxes through which the air is introduced under the perforated plates. These boxes are welded absolutely air tight and my recollection is that he said before he got these boxes absolutely air tight, he could do nothing with this system.

MR. E. C. HILL:—This is very likely to happen. There are, though, other factors that enter into this particular question. One of these is the amount of gas you are putting through and the character of the gas.

The practice in an up and down type of kiln, is usually to burn coal which produces a good deal of gas and often that gas and air comes down into the flue and is not consumed at all but up the stack. That point was particularly brought out to me once when we failed to use Pocahontas coal. The fact was it took more coal to finish our kilns that it did with the Indiana coal, bituminous, with high volatile carbon.

In an up and down draft kiln you have a hundred or a hundred and fifty feet of flue to burn those gases through and this gas generated in the fire box finds enough air, and will generate enough heat to bring the kiln along evenly.

MR. RADCLIFFE:—I might say that the first time we made a burn on this we raised the temperature up to about eight hundred degrees Centigrade in 24 hours and then it stopped. We absolutely could not raise it any more. We just kept on firing and after about six or eight hours, it started going up again. It was at white heat on the top of the kiln where the pyrometer couple was, but the brick work down through had not heated, and after the brick had absorbed a certain amount of heat, then the temperature went on down. We found that it was very important to make flue gas analysis to get the proper CO_2 content. In that way you could save fuel by introducing only the proper amount of air.

T. L. CARRUTHERS:—I might add that it is necessary to adapt this system to the particular type of kiln upon which it is used. Likewise,

we have found that one type of coal does not work on all kilns. On some a heavy cooking coal is desirable, while on others a lighter long flame coal works best and on others a combination of the two coals gives best results.

DISCUSSION[1] ON "SOME EXPERIMENTS ON THE FIRE CRACKING OF TERRA COTTA"[2]

MR. HOTTINGER:—Mr. Hill has done fine work and his paper contains a number of very important and vital suggestions to the terra cotta business, and I would like to have this paper very thoroughly gone into and discussed.

C. W. HILL:—I agree with the Chairman that we have here a very profitable piece of work. I think that we all realize the extent of this trouble, and the amount of work that is going to be necessary before we really reach definite conclusions, and I want to urge that Mr. Hill go right on the way he is going, because he has started in the right direction; and if anybody else attempts to follow this up as closely as he has, it will mean a lot of duplication of work.

I am especially interested not so much along the line Mr. Hill suggests, *i. e.*, the further investigation of the composition of the body, although undoubtedly that is important, but in a little more extensive work on the rate of cooling with reference to temperature zones.

We have broad indications that terra cotta is more susceptible to changes in dimensions at certain temperatures than others, and that this is true of the strains which relate to certain zones. That is, we can probably cool very rapidly through one zone, directly after the firing, then possibly there is a lower temperature where we have to cool more slowly. Finally, I have the feeling that the temperatures below those indicated in the charts are equally as important as the others. We should know how low we can cool a piece of work before we take it out of the kiln, without subjecting it to the dangers of the atmosphere. I do not think we know this exactly, but the lowest temperature is when all of this dangerous contraction has taken place. If we could determine it, it would be of very practical value.

There is one interesting point in connection with the Crossley and Enterprise clays. We have noticed that the Enterprise clay has changed materially in its properties during the past year, and we have found that the sand content is lower, so that Enterprise clay now is about the same as Crossley clay, and there is a material difference in its physical properties such as shrinkage.

Crossley clay has also changed considerably over what it was a year or

[1] St. Louis Meeting, Terra Cotta Division, Feb., 1922.

[2] E. C. Hill, *Jour. Amer. Ceram. Soc.*, **5**, 299 (1922).

so ago, so that it is possible that some of the conclusions that Mr. Hill drew from his analyses would not necessarily be pertinent at the present time.

I think that we have something here that is of extreme value to us, and I hope that Mr. Hill will carry along not only the lines that he suggested but also the matter of the right cooling, with reference to the special cooling zones.

E. C. HILL:—In regard to the Enterprise clay, I would say that these trials were made more than a year ago from shipments of clay made in 1920. Shipments of this clay, as Mr. Hill (C. W.) says, have shown a marked improvement, particularly in the reduced sand content.

MR. MATHIASEN:—I ran into some dunting last summer, and when we looked for the cause of it, we found that our last carload of sandy clay, which came from Woodbridge had an abnormal amount of free sand. So I was interested in that Pennsylvania sandy clay. I understood you to say that you had the most firecracking with that material, didn't you?

E. C. HILL:—Yes.

MR. MATHIASEN:—Did you find out how much sand there was by analysis?

E. C. HILL:—No determinations were made of the sand content in the clays in Series I. The sand retained on a 200-mesh screen was determined on the terra cotta clays in Series II.

MR. MATHIASEN:—To check up what he said then about this crazing, I understand you think fire dunting comes from free sand.

E. C. HILL:—I think a sandy clay is more likely to firecrack than a non-sandy one; but you can not tell whether it is going to crack or not until you try it. The amount of sand that is contained does not always indicate its character.

MR. F. B. ORTMAN:—On the question of the effect of sand in the body in causing cooling cracks, I think it should be noted that the tendency to cool-crack is not always increased in proportion to increase in silica content of the body regardless of the character of the other constituents of the body. It is quite possible that a certain silica content might be perfectly harmless in this respect whereas in another body it would be very detrimental.

On the Pacific Coast, certain companies use bodies of a very open structure in which a very high percentage, in some cases as high as 30% to 35% of a material, known locally as Ione sand, is used. This Ione sand is a mixture of pure china clay and fine-grained silica, in proportions of approximately half and half. In the use of a certain body containing 30% of this material, there would, therefore, be 15% of pure sand, which when added to the silica introduced by the other ingredients of the body, would probably bring the total silica content easily above 20%. I know of such a body to have been in use for two or three years and when upon learning of the high silica content, I made a special effort to look into the

matter of cooling cracks, and much to my surprise, at that time, found that the material manufactured with this body was practically entirely free from any cooling cracks whatsoever, even though no special effort had been made to cool the kilns carefully.

The explanation obviously lies in the fact that the body as a whole was of a very open structure and that the silica was exceedingly fine grained, so that whatever volume change took place in the silica grains themselves did not exert any decided action upon the piece as a whole.

One other point I wish to make is in reference to the rate of cooling. If we could be absolutely certain in cooling a piece that we were cooling all parts of that piece at exactly the same rate, we could, no doubt, cool very much more rapidly than we do now. In my opinion, a great deal of the trouble from firecracking is due to strains that are set up by unequal cooling of different parts of the same piece. In the cooling of an ordinary periodic kiln, certain drafts are set up through different portions of the kiln and it is certain that in many cases a part of one piece may lie in this draft or current whereas the remainder of the piece may lie in relatively still atmosphere. That portion of the piece lying in the draft would undoubtedly cool faster than the remainder of the piece and would set up a strain which might very easily cause the piece to crack. This would indicate that the method of cooling is of even more importance than the rate of cooling.

If some means could be devised for eliminating the difference in the rate of cooling in the different portions of the kiln, it would go a long way toward eliminating firecracking.

MR. SHEFFIELD:—I missed the point as to what effect more grog has on firecracking.

E. C. HILL:—Increase of grog reduces the tendency to firecrack. I might add that when all grog finer than 40 mesh was used, the tendency to firecrack was quite marked. When all grog coarser than 40 mesh was used, there was much less tendency to firecrack. However, the body with the grog coarser than 40 mesh did not seem to be appreciably better than the body containing both fine and coarse grog, so that it is hardly likely that the tendency to firecrack could be greatly reduced by taking out the fine grog.

MR. HOTTINGER:—There is one point I would like to make here; that is the sand in the body itself.

It seems to me dependent on the character of the clay itself, that is, if we have a very dense burning clay and we add sand to it, we are going to have set up a great many more strains than if we had an open burning type of clay which is not so dense, such as is able to resist the strain of the individual expansions of the sand particles themselves. When we speak of sand in the body and what effect it would have, we always have to keep in view the character of the clay bond.

C. W. HILL:—In that connection, I think we should realize that this work is being done in a practical way. We could not do it in the most scientific way on account of the time, but it seems to me that we are putting all of these different bodies of clay through more or less the same temperature treatment, and are comparing results. If we could determine the most advantageous cooling rate for each one of these different bodies, we might have entirely different results.

MR. RADCLIFFE:—I do not know, but as an opinion, it seems to me that a clay and a grog should have very nearly the same absorption for the burning of terra cotta. In other words, if we are going to have a body with an absorption of 10%, our grog and clay both should be fairly low in free sand or silica, and they both should have about the same absorption. With a vitreous and a porous body, it seems to me that there is sure to be a difference in the expansion and contraction of those two materials, which will set up a strain.

It seems to me that a good experiment to make along that line would be as follows: Have some of these clays washed; calcine the clay in the regular kiln and then make a body, using 35 or 40% of this calcined clay and the raw clay; grinding the grog to various grades of fineness, and then putting them through a test by heating it up to a certain degree of temperature, and then plunging in water. I believe that would be a quick method of determining whether or not they have a tendency to cool and crack.

I would like to have an expression on that as a method of testing those materials.

A MEMBER:—We had occasion recently to make a harder body on a small job and we used one of our tight burning clays. On this particular order we got firecracking. That is a case where calcined clay was directly responsible for firecracking. We had been replacing sagger grog by a calcine of one of the clays used in the body.

A MEMBER:—Was it a sandy clay?

A MEMBER:—No.

A MEMBER:—What porosity or what absorption?

A MEMBER:—It was the tight burning clay; its absorption was one and one-half to two per cent; one of our tight burning clays.

Using the same mixture of clays, we got a lower absorption using porcelain grog than we did when using sagger grog. By substituting the calcined clay grog for the porcelain grog, with this same mixture of clays, we got about two per cent. We also got firecracking. This small order was burned in the regular kiln with other material made of the same clay but using sagger grog. The cracking apparently was not due to the clay. It was the small particles of the distinctly different material. That is the only cause I could see for firecracking in those particular pieces.

A MEMBER:—There is no question but that a dense body will cause cool cracking.

E. C. HILL:—The only way to determine the effect of the density or porosity on the tendency to firecrack would be to fire the same body through a range of temperatures. I did not do this because I did not wish to fire our kiln very much above cone 6. I considered adding various amounts of fluxes to the body and so get bodies of different porosities, but this would be determining the effect of the fluxes on the firecracking tendency, rather than the effect of porosity.

A MEMBER:—I differ with Mr. Hill on the use of Campbell's clay. We also have used a body made entirely of Campbell's clay and grogged on a small order and had no cracking.

E. C. HILL:—I would like to make one more point in this connection. Six years ago some experiments were made with various bodies made into rather large pieces. One of these bodies contained 65% of Campbell's red clay and 35% grog and was fired at cone 6. This body had an absorption of about 9% and there was no firecracking on the trials whereas there was considerable firecracking on the trials of the bodies with the more sandy clays with absorption as high as 17%.

MR. HOTTINGER:—In speaking of this Campbell clay, I believe it to be a clay containing a rather high amount of iron.

Now, possibly all terra cotta men who have had experience in years gone by, that is, in the time when we had a lot of red colored body, remember that some of those bodies were practically as hard as granite. I can recall very distinctly that in those days, we had very little trouble with firecracking.

DISCUSSION[1] ON "REFRACTORIES FOR OIL-BURNING FURNACES"[2]

1. **Fire Clays.**—(*a*) For the raw fire clay batter or dope used in laying fire brick. Required analyses of these clays from the principal beds now worked for commercial use. (*b*) For "target" oil firing to receive impinging oil flame and to maintain incandescent mass of refractory material, as flint clays; and so to utilize most fully the principles of surface combustion.

2. **Refractory Tile.**—Use of refractory tile or baffle, flat and segmental, to receive impact of oil flame and utilize maximum heat transfer, by radiation therefrom, and so to reduce to a minimum the heat transfer by convection from the oil flame.

3. **Fire Brick.**—The manufacture of high duty fire brick for oil fired furnaces. Required: typical examples of successful application of

[1] Refractories Division, St. Louis Meeting, Feb., 1922.

[2] See Grant, "Refractories for Oil-Fired Furnaces and Boilers," **4**, 390 (1921).

these fire brick under the extreme conditions of temperature, and the characteristic flame action of all burning equipment.

4. Refractory (High Temperature) Cement.—(*a*) For laying the fire brick, instead of raw clays batter. (*b*) For washing or coating of the finished surfaces to secure all joints against erosion and penetrative effects of flame action.

MR. GREAVES-WALKER:—This is a large order. Instead of taking up this question by sections, we shall discuss it as a whole. There is no doubt that the subject of refractories for oil-fired furnaces is a live one. There is probably more loss encountered in supplying refractories for this use than in anything else we run into. The use of fuel oil is growing. Extremely high temperatures can be obtained. Furnace temperatures around 3000 to 3100°F (the softening point of most No. 1 refractories) is easily and often obtained with oil as a fuel. Further, there is a physical reaction of some kind that destroys fire brick in an oil furnace.

An instance came to my notice a few days ago of an oil fired railroad tunnel kiln. I noticed the saggers were set so as to have a wide channel through the center of the car. These cars were not pushed continuously through the kiln but pushed down one car at a time. These openings came directly in front of the burners and the flame shot straight through between the saggers. I asked why this was found necessary and was told that in three or four trips through the kiln the saggers would be destroyed if the oil flame was allowed to impinge upon them, but by allowing the flame to shoot between the saggers they could get about 75 trips out of a sagger. Under the flame action the saggers rotted—they did not melt or crack but they became rotten and were of no further use.

That is the same difficulty they are having with refractories in the linings of oil-fired furnaces. The fire brick actually rot under the oil action. My theory of it is that the oil being shot into the furnace in a fine spray is impinged upon the brick and minute globules of oil vapor are exploding on the face of the brick constantly. It is a very small explosion but you have millions of them occurring every minute and it gradually destroys the surface of the brick. If it is a thin section it will destroy the whole section, or at least make it shaky. There is no noise attending except the roar of the oil going into the furnace, but there is an ignition that is instantaneous, taking place on the surface of the brick. Presumably, this action is what destroys the face of the brick or causes the difficulty that is encountered with brick in this service.

A number of people are using very hard and very dense carborundum bricks. It is claimed that they stand this action without difficulty. It seems, from these refractories having stood up, that if we could get a refractory brick that is as hard and as dense as a carborundum brick it would stand this particular action to which the brick is subjected and

which has been found so destructive. I have no doubt there are a number of men here who have run into difficulty in supplying brick for oil-fired furnaces. I think there is plenty of chance for discussion on this subject.

THE CHAIRMAN:—Dr. Endell, will you tell your experiences on the other side, with refractories in oil-burning furnaces?

DR. ENDELL:—We have no oil in Germany.

PROF. PARMELEE:—Are you using no oil furnaces?

DR. ENDELL:—We had a small open hearth furnace, five tons only, heated with oil. I remember the lining lasting for only five days. Oil is too expensive in Germany, hence we do not use oil there except on a small scale.

MR. GREAVES-WALKER:—There has been, since the war particularly, a very strong tendency to equip steamships for oil burning; in fact the United States Shipping Board is specifying oil-burning boilers and some of the coal burners have been changed to oil. Although using only number one refractories they have to keep continually relining their boilers. A ship making a trip from New York to San Francisco will have to reline its boilers at the end of each trip. Some of these boilers take 8,000 bricks for a single unit. In making a trip to the Mediterranean they will stop at Gibraltar and reline and possibly again at the Suez canal as they come back. This indicates to some extent what the problem is and what the expense is.

MR. HOWE:—There are several points which come up from time to time in connection with the use of fire brick in contact with oil that may be worth while to bring up at this time. For instance, where the American brick comes into competition with the foreign brick, such as the "Glenboig," it is noticed that the dense finely-ground Scotch brick seem to stand up very well as compared to the more open American brick. When American bricks were compared, the denser seemed favored decidedly.

We have this oil problem in the manufacture of gas. The bricks used there come in contact with the oil that is sprayed in and the bricks finally disintegrate. This disintegration could hardly be due to temperature changes alone. The amount of disintegration varies to a great extent, sometimes taking place after one or two hundred burns, sometimes running up into the thousands. Another condition that may figure in this is the formation of carbon monoxide and everybody who is familiar with the operation of these furnaces knows that with a temperature of 3000°F, the conditions are present for the formation of this carbon monoxide.

MR. GREAVES-WALKER:—One of the peculiarities I have noticed in connection with the use of carborundum brick; if you will examine a carborundum brick you will notice it has a peculiar skin and there are

instances that have come under my observation where carborundum brick would stand up without any signs of failure for a certain length of time, 6 or 8 weeks, or possibly longer, and then they would go to pieces almost all at once within a few days or a week after they started to disintegrate or after they passed a certain stage. I wondered whether the fact that the brick would stand up for a certain length of time and then fail was not due to that skin being ruptured and the brick then being unable to resist any longer whatever action to which it was subjected.

I also wondered whether it was not possible for a ceramic engineer to develop a skin for an oil-fired brick. If he could develop some sort of a coating or glaze on the surface of the fire brick making in effect a fairly dense high grade fire brick there is not the slightest question but that they would stand up better because they now do stand until this "skin" is destroyed.

MR. GEIGER:—Mr. Greaves-Walker, in telling of the sudden failures of carborundum brick and in mentioning the difficulties experienced in maintaining clay refractories in oil fired marine boilers, has brought up several points that are of great interest.

The sudden failures of carborundum brick have been due largely to improper initial firing of this refractory. Before the difficulties were understood and the failure encountered, insufficient attention was paid to the burning. The result was that the brick were soft in the center and had only a very thin skin of properly developed material. After much experiment it was learned that a very elaborate and costly burning practice was necessary to properly mature carborundum refractories. Since this has been put into operation these sudden failures have been overcome, for now the entire body of the refractory is hard and dense instead of merely the surface. Other improvements have been effected, and carborundum refractories produced in the past eight months are decidedly superior to those previously made.

In the introduction of a new refractory numerous failures are met. Of course there is no universal refractory, but to determine the limitations of a new product it is tried in many places where there is every reason to doubt the possibility of success. In many instances too, a new refractory is put into places where the tried refractories are very short lived with the hopes that, through some combination of circumstances, some economy may be effected in the long run.

Details of manufacture had to be learned through failures. Carborundum refractories have failed because of misapplication and because it did not develop at first that they could not be fabricated and burned just as clay refractories.

Mr. Greaves-Walker has spoken of the necessity of replacing fire-clay linings in steamship boilers practically at the end of every trip from coast

to coast. The labor costs in installing new linings and the losses attending the holding up of the vessesl are far greater than the actual costs of the refractories ordinarily employed.

The Luckenbach Steamship Company has purchased a great many carborundum brick for their oil-fired ships at an initial cost of ten or twelve times the price of clay brick. At this time the oldest of these linings has been through five, thirteen-thousand-mile trips without any repairs whatsoever. This means that the labor costs on relining furnaces for four trips has been saved and that the boats have not been tied up pending replacements to refractory settings.

Another installation for which we have more specific figures can be mentioned. At the plant of the Mitchel-Bissell Company, manufacturers of porcelains for the textile industry, oil-fired kilns are run to cone 16–17. Repair costs to combustion chambers lined with clay refractories amounted to $2,000 in eight months. Carborundum brick, costing $500 were installed and the kilns at present have been in operation over fourteen months with no combustion chamber repairs. Apparently, moreover, the brick are just as good as when they were installed.

With carborundum brick of the quality now being manufactured, we have not had a single report of failure in oil-burning furnaces of any kind.

MR. LAIRD:—I would like to know how important the question of salt in oil is. I have known of several instances of the failure of refractories under oil firing apparently due to some material coming from the oil.

PROF. PARMELEE:—I understand this trouble is peculiar to certain oils, especially those of the Pacific Coast, if I am correctly informed.

MR. GREAVES-WALKER:—You have heard of the success of the carborundum brick in solving this problem of oil-burning furnaces, but I do not think that the fire clay brick manufacturer need be discouraged. The fact of the matter is, he has something to aim for. There is such a large difference between the price of clay brick and carborundum brick (and probably always will be) that the field is certainly worth getting into. I think it is one that will bear some study and some thought on the part of the fire clay brick manufacturer. Experience has shown that there are very few ground fire clay mixtures sold for laying up fire brick that are suitable for use in oil-burning furnaces. This is probably due to the fact that the ground fire clay almost invariably has a lower fusion point than the brick it is to lay up. Consequently, the mortar joints are the first to be attacked by the high temperatures encountered and this in turn subjects the weakest part of the brick (the edges and corners) to attack.

The original question suggested for discussion asked that analyses of clays suitable for this purpose be given. This information would not be of great value, but it can be said that for the average oil-burning furnace, fire clay mortars fusing below cone 32–33 should not be used.

For "target" oil firing, walls or baffles built of brick or tile have not proven successful. Recent experiments have shown that "targets" built of calcined diaspore in lump form analyzing 85% Al_2O_3 or above, will solve the problem. These "targets" are built in the same manner as a rustic boulder fire place, the mortar joints being of the same material as the lumps. High grade flint fire clays have been used for this purpose, but have a tendency to disintegrate or break down.

Refractory tile or shapes when used to receive the impact of the oil flame have not proven generally successful due to the fact that severe disintegration takes place and where there are wide variations of temperature, the shapes crack.

Very few, if any, of the brands of high heat duty fire brick have consistently stood up in this practice. Results have shown that the conditions require a super-refractory. So far two brands of super-refractories have proved very generally successful. These are put out under the trade names of "Arcofrax" and "Carbofrax," the former being a high alumina refractory and the latter a carborundum refractory.

The market has recently been over-run with so-called high temperature cements. Many of these have no merit whatever as refractories on account of their comparatively low fusion point. Some of them are simply ground ganister with an addition of sodium silicate and others are nothing more than a mixture of ground fire-brick bats and clay.

Asbestos, talc, and many other like materials, to which a bonding agent has been added, are also used. About the only thing that can be said in their favor is that they have a cold set, *i. e.*, they will set up before heat is applied and this property is always obtained at the expense of refractories.

High alumina cements such as arcofrax (pulverized), the carborundum cements when not diluted with too much fire clay, and ground chrome ore, have all proved very effective when used in laying up brick work in oil-burning furnaces. On account of the variation in thickness which is experienced in even the best brands of refractories, a better job can generally be done with the super-refractory cements if the brick are all laid with a trowel instead of dipped. With a trowel a perfect but thin joint can be made that takes up any inequalities on the edges of the brick and thus prevents the oil flame from getting a start in the thin opening generally left when brick are laid up by the dipping method.

There is no question but that considerable protection is given the brick work by a coating of a high grade super-refractory cement, although unless new coatings are applied the protection is only temporary as the original coating is soon disintegrated and disappears.

DISCUSSION[1] ON "A MODIFICATION OF THE MOLECULAR FORMULA FOR GLAZE AND ENAMEL CALCULATIONS"[2]

MR. STALEY:—It seems to be taken for granted that I am entirely opposed to the use of molecular formulas in compounding enamels. Personally, I have never been able to use the molecular formula with any success, and for a good many years I have used calculated melted weights instead of the molecular formula. If others can use these formulas I am willing to concede they can do something that I can not.

MR. DANIELSON:—It seems to me that the only materials Mr. Hansen has definitely placed are the fluorides. I can give him a formula similar to his example by using a combination of feldspars for which it would be impossible to figure the batch even from this molecular formula. Some of the potash, for instance, may go in as nitrate or as feldspar, hence, it is impossible to figure definitely just how much of the various constituents, potash, soda, etc., is derived from the various batch materials unless the exact chemical analysis of each is known.

MR. HANSEN:—When expressing a formula in terms of materials used so that it can be duplicated by another worker, we should know the composition of such materials as feldspar. It is not sufficient to state that "four hundred pounds of feldspar was used in this enamel" and expect that any feldspar will produce the same results. We do not have pure feldspars. To duplicate results with different feldspars on any sort of formula scheme of expression, the composition of feldspar must be known. I admit that this formula does not establish the identity of all the constituents.

You have to use a certain amount of reasoning in the interpretation of a chemical analysis, and it is no better than the way you interpret it. The scheme here proposed reduces to the minimum the uncertainty in the reasoning employed. The old formula admits of greater misinterpretation of the fluorides and this modification certainly does establish the identity of the fluorides and seems to me to present certain advantages which are worthy of being taken into consideration.

MR. LANDRUM:—We will all agree that graphic methods for the representation of facts are highly desirable. The writer of this paper has gone one step farther in giving us more data in a graphic form than is given by the old Seger molecular formula. However, it seems that he may have lost something of simplicity in so doing, for instance, in the fact that we can not tell what feldspar he used.

What is the advantage of this graphic formula over actually giving the batch mixture to start with? I think that no paper should be given, for no paper is otherwise of any use whatever, that does not give the batch

[1] Enamels Division, Feb. 28, 1922.

[2] J. E. Hansen, *Jour. Amer. Ceram. Soc.*, **5**, 338 (1922).

mixture. I would take for granted that, if the author's purpose is to give information, the batch mixture would be given.

Comparison of batch mixtures is an impossibility unless they be on a unit basis. I have had fellows ask, "What do you think of this formula?" No one can tell anything by looking at the batch mixture. Why not go one step farther and calculate the melted weights, taking into consideration the gases that go up the chimney. This is Mr. Staley's method of melted weights. A man can, by looking at two formulas, in terms of melted weights, make intelligent comparisons.

You have, even with Staley's method, so many factors to take into consideration, especially with nineteen or twenty ingredients, that no quick conclusion can be drawn.

Each one of the materials that goes into the batch mixture adds certain things to our final analysis. It adds those things that we all find in the chemical analysis. The research worker who is trying to duplicate an enamel, with only the finished piece of ware as a sample has a very difficult proposition. Anyone who has tried to do this, even with analyses that were correct, knows that he has just this same sort of synthetic problem that you have with ordinary molecular formulas. In other words, the Seger molecular formulas are those from which the analysis of your formula is made. To work backward from either you will have to use a great deal of ingenuity and much resourcefulness, and, before you have any success at all, a lot of experience in the actual making up of many batches of enamel.

I think that this method of representing the batch mixture, giving the fluorides in place of oxides, is a good one. The old molecular formula had all the soda grouped, no matter where it came from, as well as all the calcium oxides, etc., and certain comparisons could be made directly and quickly.

If you are going to get away from the simplicity of the molecular formula, I would just as soon get away from it altogether. I do not believe in taking percentage compositions of the actual materials put into the batch. What I mean is to carry that one step further and take the molecular weight and divide it into pounds, thus obtaining a factor which represents the number of molecules.

I do not see any advantage in stopping where you have. Why not, in that same form, put all the factors in one column and have them in the molecular proportion, that is, the equivalent proportions. I do not see what advantage you have gained by putting calcium fluoride in the column with the RO_5 and not putting sodium oxide there when part of it comes with B_2O_3. It really does not tell you all any more than the molecular formula, and it does lack the simplicity of the molecular. Fluorine generally has been given with the acids simply to show how much of the

soda is present as cryolite, how much of the lime as fluorspar and how much carbonate.

We do not say this molecular formula represents the final analysis of the enamel. It is simply the representation of certain facts, and we might each one use it for our own problems and publish it in our own way. I think in general we should adopt some method to present these facts. I think the old molecular formula combined with the old batch mixture tells a whole lot.

We have to go one step further to Staley's method. The ultimate composition of an enamel can be interpreted in a dozen different ways, using in one case cryolite to furnish the alumina and in another, feldspar, and still another, the oxide; and each will give a radically different result. Cryolite acts as cryolite, not as sodium oxide and fluorine. Nor does cryolite act as aluminum fluoride and sodium fluoride. I still maintain that in our papers we must give the results in terms of batch mixture as well as molecular formula.

MR. HANSEN:—Mr. Landrum brought up several points that came through my mind when I was working this out. I will admit the old method of the molecular formula used in most papers on enamels and glazes has the utmost simplicity, but in order to interpret it correctly, we have to have the original batch formula. Mr. Staley brought that out some three or four years ago in the *Transactions*. In other words, we have to keep two tables in mind when interpreting the formula. We can go to the other extreme and express our formula in terms of equivalents of each of the constituents, so many equivalents of fluorspar, so many of soda ash, sodium nitrate, etc. It seems to me, though, that such a formula would be too complex. We have to draw the line somewhere. Cryolite acts as cryolite, not as sodium oxide, aluminum oxide, and a certain amount of fluorine. This is shown by this proposed form of expression. I had to draw the line between the utmost simplicity and a certain amount of complexity.

DISCUSSION[1] ON "THE GREEN STAINING OF CLAYWARE"[2]

MR. HOTTINGER:—On this subject, I am sure we all have had some experience and probably some contradictory experiences.

MR. ALBERY:—There is one thing that we have probably missed in Seger and that is the article on green discoloration of light-colored bricks, and if you will look on page 359, Vol. I of the Collected Writings of Seger, you will find he referred to an organic growth that occurs on light-colored bricks in a moist and humid atmosphere; a growth of algae. When I was working for Mr. Gates, we had some experiments made to test this out.

[1] Terra Cotta Division, St. Louis Meeting, Feb. 28, 1922.

[2] Hill, *Jour. Amer. Ceram. Soc.* (*Bull.*), **5**, 51 (1922).

Seger recommends an insecticide as a preventive but not as a cure for the same. The insecticide naturally prevents this organic growth. We used a zinc sulphate solution, and were able to prevent the green discoloration from developing.

MR. C. W. HILL:—The organic stain mentioned by Mr. Albery is of course a different matter from stains or suspensions. The organic growth may be differentiated from the other by inspection or by microscopic examination and may be burned whereas the inorganic green stain on ignition gives a black residue. There need be no confusion as to the two kinds of stains.

MR. HOTTINGER:—I should like to ask Mr. Hill whether he tested for vanadium?

MR. C. W. HILL:—We did not test for vanadium. Since we obtained such a copious test for iron and silica (possibly alumina too) which would indicate that the material was almost entirely an iron compound, it seemed needless to bother with any small quantities of other substances. The large amount of iron was enough to explain the coloration.

As stated in the paper, as Seger's analysis showed no iron there may be green stains due to vanadium and not to iron. Our contention is merely that the stains which we have examined are due to iron compounds. Because of failure to get an iron test easily, it is probable that some stains have been attributed to vanadium that were iron stains. Certainly before blaming it on vanadium, one should make certain that the stain is not due to iron compounds.

MR. ALBERY:—The one sure preventative for the appearance of green discoloration, organic or inorganic, is the use of impervious slips.

DISCUSSION[1] ON "A NEW TYPE OF GAS-FIRED VITREOUS ENAMELING FURNACE"[2]

BY A. STOCKSTROM:—After three months of operation we have no fault to find with our gas-enameling furnace; in fact, the results have been more than satisfactory. The quality of our ware has improved, our cost of production has decreased and the service from the enameling department to the assembling departments has greatly improved.

Having previously used only coal fired muffle furnaces, with which temperature control is very difficult, we attribute the improvement in quality not only to the fact that the enamel is fused at a decreasing temperature, but also to the accurate burning temperature obtainable. The flexibility of control also makes it possible to quickly change the kind of ware being burned or the kind of enamel, which is a great help in a plant

[1] Recd. August 1, 1922.

[2] H. H. Clark, *Jour. Amer. Ceram. Soc.*, **5**, 478 (1922).

where many different parts are needed daily in order to keep the assembling departments supplied.

However, our main object in trying a furnace of this kind was to get away from furnace breakdowns and the consequent expense and interruption of production. Our furnace has now been in use approximately 2,160 hours and the brick work is apparently in the same condition as when put in. During this time it has been entirely shut off every week from Saturday noon until Monday morning.

On Monday mornings it takes about 40 minutes to bring the furnace to working temperature.

We use artificial gas of 580 B.t.u. per cu. ft. quality and our consumption from April 14th to May 15th was 835,000 cu. ft. or total cost for gas $710 during which time the furnace was in operation 510 hours, which shows an average hourly gas consumption of 1640 cu. ft. per hour or an hourly gas cost of $1.40 with gas at $.85 per 1000 cu. ft. During this time we turned out 137,700 sq. ft. of ware with this furnace or 270 sq. ft. per hour, which gives us a fuel cost of $.52 per 100 sq. ft. The ware consists of flat sheet iron parts ranging from 24 to 18 gauge.

We are not able to determine at this time the exact saving as compared to coal furnaces as we do not know what the life of the gas furnace will be, but from all indications the furnace will need no repairs for some time—in fact, it should last almost indefinitely.

AMERICAN STOVE CO.
ST. LOUIS, MO.

DISCUSSION[1] ON "PHYSICAL DEFECTS IN TANK BLOCKS"[2]

MR. LOOMIS:—This investigation was made for the Corning Glass Works. We examined the structure of a number of tank blocks to determine the number of fissures. We chose several makes which we had in stock and took blocks from carload shipments. These blocks were cut into sections about 3 inches thick, and note was taken of the number of fissures and other defects present. There was only one make of block examined which proved to be totally free of fissures or defects.

I believe it is generally conceded that fissures are detrimental to the life of the block, and therefore to the life of the tank, since the glass penetrates the fissures, especially if they are of any size. In all cases but one, we found fissures varying from $^1/_4$ to 3 inches in length and quite a number of holes $^1/_4$ inch in diameter. Some of the blocks were very badly laminated; but in one case there were no defects of any sort in the three blocks chosen. The blocks examined were taken at random from the shipments. It looked as though one maker, at least, had found a method

[1] St. Louis Meeting, Feb., 1922.

[2] Loomis, *Jour. Amer. Ceram. Soc.*, **5**, 102 (1922).

of making perfect blocks, or was using closer supervision. This paper was presented with a view of pointing out the possibility for improvement and was written from the standpoint of the glass manufacturer rather than the block maker.

MR. ZOPFI:—I would like to ask Mr. Loomis if the block that showed no defects gave a longer service than the blocks that showed defects.

MR. LOOMIS:—In this particular case, they did not, but other things being equal, the better-made block, it is to be expected, would give better service. I do not believe any body will disagree on that.

MR. ZOPFI:—I grant you that, Mr. Loomis. We had occasion within the last six months to examine some blocks that were perfect in mechanical structure and denseness but they did not compare in service with blocks that we knew to be defective, that is, which had laminations and fissures.

MR. BROWN:—Several years ago I saw a bottle tank that lasted less than four months. The reason was sought. Examination showed many places where glass had penetrated nearly through the blocks. The blocks not only had spalled unduly but large pieces had cracked off where the glass had eaten back into the fissures. Many voids existed in the blocks and at some of these holes finger prints were easily seen on the clay. In making the blocks not sufficient care had been used in bonding the different layers. This instance was an extreme case of fissures in blocks.

MR. LOOMIS:—There is more of a chance of the blocks being rapidly attacked if made with fissures or laminations than without them. You can more readily predict how long tanks with well-made blocks will last than when one or two of the blocks are poorly made. Poorly-made blocks will let the glass eat through, which means either making a hot repair; or the tank being put out.

MR. FISSE:—I find that a great many of the manufacturers want extremely large blocks. I believe it to be the consensus of opinion of the men making blocks and also some of those who use them, that a smaller block will give the best results.

For the making of a block that weighs in the neighborhood of twelve hundred pounds the average glass manufacturer will allow about four months. How is the manufacturer going to know whether that block is thoroughly dry on the inside? He can not tell. When a block with a wet core is burned, steam will be developed causing a fissure. The wet clay portion will part from that which is dry.

During the war we had some bad coal. Suddenly we obtained some good coal. The firemen did not know the difference, hence they shoveled in the same amount of this good coal as they had of the poor grade. In consequence the heat increased too rapidly and cracked the blocks. Those blocks were shipped and the customers made complaint about cracks.

After about a year they asked, "Can you not send us some more cracked blocks?" They had gotten very satisfactory service out of them.

MR. GRAFTON:—The answer to that is with the good grade of coal they burned the blocks all the way through. They got a splendid burn in the blocks, perhaps a better burn than usual.

I never made tank blocks with pug mills. That is the only way I have not made them.

The blocks Mr. Brown refers to must have been some I once heard of where the manufacturer placed wire in the blocks when they were made and then pulled the wires out to provide air spaces so the blocks would dry quickly.

Of all the blocks I have seen, I find the blocks are made best by making them by hand; that is, laying them in the same manner you would lay the bottom of the pot, starting with a layer about 1 inch thick and then laying each layer at right angles with the previous layer. After the block is built up the spare clay on the sides and ends is cut off with wires; drying and burning in the usual way.

I do not agree with Mr. Fisse that blocks are going to show a defect when they are burned on account of being large blocks. That is simply a question of proper burning and proper drying. I agree that you can not hasten the drying. The drying of twelve hundred pound blocks is entirely different from the drying of those weighing only 230 pounds.

Nearly all blocks will show some defects, small holes, drying cracks, etc., but I always felt safer in cutting blocks that had been laid by hand because we never found any defects to any great extent in such blocks.

You may wonder why we do not manufacture in this fashion. The answer simply is we can not afford to do so, and the glass man does not wish to pay more than the generally accepted market price for his blocks. In laying them by hand you have to use softer clay, hence they take longer to dry and you have to have five or six dollar a day men to do it, and not the old time two or three dollar men. It is simply on account of the expense that we do not make blocks by hand. I think, however, that better blocks would be made that way.

MR. ZOPFI:—I want to support Mr. Fisse in his argument that a large block can not be made successfully or burned successfully with the same material in comparison with a smaller block. You can make a smaller block much better, and you can burn that block to a high temperature more uniformly through it than you can a large block. The higher temperature you burn a block, the more serviceable it will prove in the furnace.

MR. FISSE:—I wish to correct Mr. Grafton's interpretation of my statement. A large block can be made without fissures. I know this to be true. The making of it, however, requires a much longer time. No

man should expect to make a block eighteen by thirty-six by forty-two in four months, because it can not be properly done.

MR. AURIEN:—Mr. Fisse is in the Clay Department of the Mississippi Glass Co., hence has an opportunity that other fire clay manufacturers do not have. When he wishes to make an experiment, they do it at the glass works. We are the goats. They have made a great number of large blocks which we have used in our 600-ton tank, with good results. These successes with large blocks are due, I believe, to the fact they have given time to thoroughly dry and burn them. If large blocks are given plenty of time to dry and burn, they will be good. The smaller block is easier to make however, and, as a rule, gives more economical results.

MR. DIXON:—I am a builder, hence use blocks in the building of furnaces. It has always been my opinion that any lamination or crack or joint in a block is a defect. It is just the same as having too many horizontal joints in your tank wall. The alkali fumes will penetrate them and attack the block. That has always been my conception even when in the block business myself.

In contradiction to that, here is an odd thing. In the eighties, when they were just starting to build tanks in this country, Belgian engineers came here and built three window glass tanks. They shipped the blocks from Belgium. I never saw such a mass of clay in my life. They were as irregular as rough stones. They had stone masons chiseling those blocks into the sizes they wanted and there was not a single surface that was not full of holes, crevices and fissures.

These blocks came from where they had developed tank furnaces, and had used them for years. Afterwards, I went to the plants where they made these blocks. No one here would ever think of making a block like they made and still are making. They use moulds without bottom, just the frame. This they set on a board, and put a prop between the ceiling and the mould. They make the clay in a pit just as we do here. They roll a lump of the clay on a table by hand and then chuck it into the mold. They fill one corner and then the other corners one after another. The clay is just absolutely gobbed in. In this careless manner they fill the mold. They then find the clay has pushed out under the mould frame and has raised the frame at least an inch in spite of the prop or brace. They let the block stand for a couple of days until it stiffens, and then trim it with a long knife to make it nearly square and of proper dimensions. Yet their blocks seem to stand just as long as ours, and their furnaces give just as good service as ours.

We go to a lot of trouble in making blocks, that do not stand one day longer than theirs. Now, why is this?

This is a field worthy of investigation. Is it not natural to suppose with all the pains we take to make blocks, they should give better service?

I read the article by Mr. Loomis and I agree absolutely with what he said. I can not believe that a block full of cracks and lamination crevices can stand up as well as one that is put together in a good homogeneous, careful manner. And yet, why we do not get the service out of the better made blocks?

MR. HAUSER:—I would like to ask Mr. Loomis if he thinks a tank block can be too dense.

MR. LOOMIS:—Naturally a block can be too dense. If it is too dense it will crack when being heated up in the tank. If somebody gets an idea they can get a tank ready for production overnight, or in one or two days, the blocks are very apt to suffer, and in that case too dense a block is a very serious thing.

MR. WRIGHT:—Mr. Dixon made a statement which was somewhat surprising to me. Dr. Turner, after touring this country wrote a summary of his trip and I believe he stated that the American manufacturer was obtaining longer service from glass tanks than the English manufacturer. There seems to be a difference of opinion.

A MEMBER:—I believe Dr. Turner pointed out that almost universally in this country, perhaps window glass excepted, we use soda ash which is less corrosive than salt cake as used extensively in England.

MR. DIXON:—The three tanks mentioned actually did give a very long service. Of course, at that time the window glass manufacturers in this country used salt cake entirely. Through information received from other sources I have learned that we do not get any longer service from our tanks than they do over there, but we must remember that in England there is only one factory of any consequence making window glass. It is only recently they have copied American installation. Previous to the war they bought most of their plate glass and window glass from Belgium or in Germany; most of it in Germany.

I wish to mention one other thing in regard to blocks and the life of blocks. You will hear it said that if a bottle or jar manufacturer gets twelve months out of his tank he is mighty well satisfied. The decolorizer they are now using is worse in its effect on the blocks twice over than manganese. I can not tell you why, but it is true.

MR. AURIEN:—Mr. Dixon's discussion is vitally interesting to me. It is just recently that we began the use of selenium and cobalt decolorizer. When in place of eight pounds of manganese in a thousand-pound batch we use one ounce of selenium and cobalt decolorizer, one would hardly expect that it would affect the block.

I wish to refer again to longer life obtained from small blocks. We used to, on many occasions, run twelve, thirteen or fourteen months without a hot repair, and again we would run 10 or 11 months or stretch our run to 16 months, which we thought was a fairly good run. Now, we go twenty

and have gone as long as twenty-two months and a half without a hot repair. I can not tell the reason for this longer run now in comparison with former times, but I think it is because we build the tanks with straight-line joints and have broken the joints properly, and have used smaller blocks.

We make figured glass and wire glass. We fill 150 to 180 tons of material in 24 hours per 600-ton tank, not for one day or six days, but twelve, sixteen, eighteen and twenty months. We believe this larger capacity and longer service is due to straight, even joints and not using too big a block.

MR. HOSTETTER:—You use floaters?

MR. AURIEN:—We just use one set of floaters.

MR. HOSTETTER:—No bridge wall?

MR. AURIEN:—None.

MR. YUNG:—I would like to know what you mean by the life of a tank. Lots of people think the life of a tank means the time from the start of fire until the fire goes out; other people think it is from the time you have the glass melting until you make your hot repairs. In comparing the life of tanks, it seems to me mighty important to understand in what units you are talking.

I would like to substantiate some things said by Mr. Loomis. The largest burden of proving the value of sound blocks ought to be up to the block manufacturer rather than the glass manufacturer.

For quite a few years now, I have taken a photograph of the tank on the inside every time one goes out. This sort of a record has shown some very peculiar things. With blocks from the same shipment and supposedly of the same batch, you may have one block flux down to $^1/_2$ inch, while the others stand up to 6 or 8 inches. This, it looks to me, is a question of workmanship. I have seen other blocks standing in which holes and cracks would develop into which you could put your hand for 6 or 8 inches. Such irregular service, it seems to me is up to the block manufacturer to overcome, for if they were making uniform blocks the blocks would naturally wear uniformly.

MR. AURIEN:—We consider a run from the time we make our first cast. Probably the life of a run is due somewhat to the time taken to heat up the furnace. Suppose they direct me to start Number 4 furnace on the first of March. I will tell them that on April first we will make our first cast, and not before. We might shade that time a day or two, but roughly it is one month from the time we start a furnace to the day we make the first cast.

I have heard of instances where they will put fire to a furnace and in ten days after that make a cast. This I think is absolutely all wrong. You are doing an injustice to a tank block. There is no doubt about that. We take thirty days to heat the furnace to the casting condition because

we think it adds to the life of the furnace. If we get twenty-one months out of our blocks why can not those who use the same blocks?

MR. HOSTETTER:—Do you start with a full cullet melt?

MR. AURIEN:—Absolutely, we start off with a full cullet melt, and about 4 or 5 days before we are ready to cast we start to fill the batch.

MR. HOSTETTER:—A green tank?

MR. AURIEN:—Yes.

MR. DIXON:—Mr. Chairman, that very thing is the secret of his success. Naturally he fills every joint, lamination and everything else with molten glass so that all of the joints are sealed and glazed.

I am convinced there is no use making the blocks very thick. The walls of the first ones built in this country were 39 inches thick; think of it! Inside of a week or two eighteen, nineteen or twenty inches would slough off into the glass.

A concern using 8-inch blocks in a flint glass tank began to have trouble in about 8 months. Glass was coming through the joints. They complained that the tank did not run as long as it should. By inquiry in the factory I found that in nine days from the time that tank of 250 tons capacity was repaired with those eight-inch blocks, they had poured glass. Nine days after they lit the fire! I said, "Gentlemen, you need not tell me anything more." Think of it: They were pouring glass in nine days and then had the nerve to kick about the blocks.

MR. FISSE:—We shipped a concern almost a complete tank. We also shipped blocks to one of their nearby neighbors, also in the window glass industry. The blocks to both concerns were probably made out of the same batch of clay. The first one got about eight weeks out of his blocks (eighteen-inch wall) the other one got in the neighborhood of sixteen weeks. When those blocks that lasted only eight weeks were taken out, an arm could have been shoved into the fissures. The blocks were thoroughly permeated with glass.

Now, the whole proposition is this: they were not burning off the salt and water from their batch, but allowing them to saturate the blocks because the end of the fire was playing into the checkers. The other concern had the end of the fire in the combustion chamber and was burning off the salt water. It is the salt water that does more damage than anything else. You have to get rid of it.

MR. BROWN:—Mr. Aurien has stated he has run a 600-ton tank making wire glass, for over twenty-two months without any kind of repairs; I would like to ask if water coolers were used on the furnace.

MR. AURIEN:—I will say this, with absolute frankness, that the last twenty-two months run which we had on our big No. 4 tank, there was not as much as a brick or a handful of clay added to that furnace. After the first eleven or twelve months' run, we applied air in all spots that

showed a little bit red, and we maintained that air there until the furnace was out. Did I answer your question?

MR. BROWN:—Yes, that is very interesting. I think Mr. Dixon may be able to tell us if, when you put water on a tank to cool your blocks, your salt water is liable to run over to that cold side of your furnace and thus get one thing fighting against the other.

MR. AURIEN:—I may answer just that portion of your question. We have very little to contend with regarding salt water. Our batch is a 1000 pounds of sand, 370 pounds of limestone, 320 pounds soda ash, 58% dense and only five pounds—just imagine—only five pounds of salt cake. At times we would not necessarily need the salt cake; that is, not every day. About Thursday, Friday and Saturday of each week we add salt cake to get rid of our crust. You can imagine that our salt water is nothing.

There are very few manufacturers who would dare to wash out their checkers with 75-pound pressure water through a two and a half inch fire hose. We do not do this until after a five months' run. This is to allow sufficient time for the checker brick to become dense, *i. e.*, lose their porosity. If they are new and open and you apply the water onto new pores you would choke them all up, but after they are well burned—say after five or six months—they will then wash clean. We do this on Sunday morning and it only takes about thirty minutes to do it. We go through every checker once and then in a half hour we wash them again. Some of you are laughing, but it is a fact.

A MEMBER:—That is true.

MR. AURIEN:—We credit the longevity of our furnace to that one condition.

A MEMBER:—Did you ever take steam?

MR. AURUEN:—I believe you could use steam. Your checkers are hot, hence water answers the same purpose.

MR. DIXON:—That is not really new. I saw that done over thirty years ago. You can only do that though, if the accumulation is in the form of dust.

I know a man who actually built a tank of wood and melted glass. I know that to be an absolute fact.

MR. AURIEN:—I beg your pardon, gentlemen, but Mr. Dixon has gone me one better.

MR. DIXON:—He built double walls of planks, and between them he had water flowing, a water-cooling proposition that was unique. He actually melted glass in it. But here is where he fell down. He neglected to protect the plank at the glass level. If he had put an overhanging block on the wall above the plank wall to protect it, he would have gone on melting

glass. That was done in New Jersey. Then you talk about laminations in tank blocks.

MR. BROWN:—It has been my understanding that about the same batch is used for wire glass as is used for window glass. Since Mr. Aurien's batch contains practically no salt cake it would be expected to have less corrosive action on tank blocks than does a window glass batch containing considerable salt cake.

MR. DIXON:—Do you not know that window glass people use salt cake because it gives a lustre and brilliancy that you can not get from soda?

MR. BROWN:—Here is a man getting along without it.

MR. DIXON:—Of course, there are lots of them doing without it, but he is making wire glass. He is not making the glass you are making. They use the salt cake because it gives window glass a brilliancy and lustre that they do not get from soda. Soda ash glass in a window will finally get dim and will not retain the lustre and brilliancy as will the salt cake glass.

DISCUSSION[1] ON "THE HANDLING, STORING AND SETTING OF GLASS POTS"[2]

MR. DIXON:—Mr. Forsyth failed to touch on one important feature from a furnace builder's standpoint, and that is the care of the bench of a furnace. We have had any number of cases where furnaces have lasted without repairs from five to six years; in one case seven years. We have had other cases where they have gone out in one or two years and they wonder why they fail to get the same service. The answer is that every time they set a pot they do not fill the gulleys that they find on the bench of their furnace. Those gulleys should be filled so that the glass will not continue flowing through that same channel and eventually eat its way to the bottom part of the furnace. Those who take the precaution every time they set a pot to keep their bench in repair are the ones that get long life and service from their furnace, and that is a mighty important feature, for the rebuilding of a furnace is a very expensive proposition.

There is another matter in setting pots; every pot has a concave bottom. No matter how carefully you spread sand on the bench with a rake or any other kind of tool, it is impossible to get an even bearing on the bottom of the pot, which has to carry the entire weight of the glass, unless the pot is worked back and forth two or three times until it absolutely beds itself in the sand underneath. This gives the center of the bottom the same support as it has around the outside and prevents the bottom from dropping out.

There are some very funny things that happen in the handling of pots.

[1] Discussed St. Louis Meeting, Feb. 28, 1922.

[2] Forsyth and Clark, *Jour. Am. Ceram. Soc.*, **5**, 146–50 (1922).

As I remember, years ago when we were in the pot business, we had a complaint from customers to whom we had shipped carload after carload of pots. They complained that they all either broke in the bottom or cracked around the wall at the bottom. It became so serious that we went there with a carload of pots to observe how they handled them.

They had a pot carriage and they carried them from the car, and everything of that sort. Their pot carriage had a small swivel wheel in the center that enabled them to turn around almost within the circumference of the pot, which was very convenient, but to do this turning they took two pieces of about one and one-half inch hemp rope and laid them crosswise over the carriage which, when the pot rested on them, gave them four points to pull on. Now where those ropes crossed right underneath the pot there was a hump that sustained the entire weight of the pot and when they pulled the pot over to the place where it was to be stored the whole pot was riding right on the center of the bottom which is the weakest part of the pot. That was the trouble and the problem was solved and they only found it out after they had ruined three of four carloads of pots.

MR. FORSYTH:—I would like to ask Mr. Dixon if the channels he means are those from the back of the pot down to the slag holes?

MR. DIXON:—Yes.

MR. FORSYTH:—That, I will admit is not touched upon at all in our paper, but the matter of getting an even cushion under the pot was implied by the word "settled" but not discussed in detail.

A MEMBER:—I would like to ask Mr. Forsyth, if he ever had any experience in raising the pot off of the bench, that is, elevating the pot?

We had one glass manufacturer send us specifications to make a pot with channels on the bottom, if I remember correctly, about four stilts or three stilts on either side, radiating from the center and about ten inches high. When the pot was set in the furnace this would allow a passage of heat underneath the pot. I presume the object was good melting.

It has always been customary to set pots on the bench of the furnace. The Sneath Glass Co., of Hartford City, Ind., had a fire clay bench in a furnace that I know was in operation for 16 years. They were very careful when they removed a pot to fill up all the crevices, as Mr. Dixon would put it, and it looked foolish the amount of time they would take in leveling off that bench. The bench was always carefully prepared for the pot and I noticed that they always scraped out the middle of the sand before the pot was set back and then it was shifted around as Mr. Dixon described in order to settle it.

Now we all know that with existing conditions the fire can not get at the bottom of the pot. The general practice throughout the country is that the temperature of the pot arch is not brought up to the temperature of the furnace. In many cases it is as low as 200°F, below the temperature

of the furnace. Therefore, the pot will not be burned as hard in the pot arch as it will be in the furnace and if it is set with the bottom on the bench it is certain the bottom will not be burned as hard as the rest of the pot. I remember our customer showed me the pots that he was using and I remarked that he would surely have to set them on the bench and he replied, "No. It may not be done elsewhere but we are elevating them and getting successful results."

MR. FORSYTH:—I will have to confess that practically all of my experience with pots has been at one plant, and I believe I can safely say we have an exceptional man in charge there. It is a hobby with him to take care of his furnace. We have one furnace that only needs a fire in it to start it up after seven years of operation. I think Mr. Dixon is familiar with the furnace.

We have tried putting the pots into the furnace on jack bricks and then taking down the breast wall and letting them down again. Our experience has been with all such tests that an assertion on a few tests is unreliable. We prefer to make a statement only after a considerable quantity have been so tested. As we only tested a few pots in this particular manner the results were not considered conclusive. As I remember, we attained good results but nothing extraordinary.

DISCUSSION[1] ON "OPERATION OF LEERS[2]

MR. PAYNE:—Mr. Adams objected to the phrase that Mr. Frazier used when he spoke about "the temperature at which the strain is introduced," and claims that there is no strain in the glass until it is at a low temperature. At our factory we use a pressure of five thousand pounds per square inch in the making of tumblers. With this pressed ware we have much more trouble in getting satisfactory annealing than with articles of the same size and weight made with low pressure. On the Owens machine, a pressure of about 18 lbs. per sq. inch, the annealing is much easier than with tumblers. We feel very sure that strain is introduced when the plastic glass is compressed at a temperature above the annealing region. That is, we think strain is present before the temperature of the glass has been lowered to 1000–900°F. As I understand Mr. Adams, it is his belief that there is no strain until these temperatures are reached.

MR. HOSTETTER:—You have a higher initial strain, in other words, than you do in using lower pressure.

MR. PAYNE:—That is our opinion. We press from five to eight thousand pounds per square inch.

[1] Frazier, *Jour. Amer. Ceram. Soc.*, **5**, 37–42 (1922). Adams, *Ibid.*

[2] St. Louis Meeting, Feb. 28, 1922.

MR. HOSTETTER:—May I ask what the difference in thickness of the ware is?

MR. PAYNE:—About the same in either case. That is, all the way from a half inch at the bottom to an eighth inch in the tumblers, and in some of the bottles we make, it would be almost that thick in the bottom.

MR. DIXON:—Isn't it true, you get a strain in the initial process of pressing the glass from the mere contact of the iron?

MR. PAYNE:—It was our opinion we were getting some due to the enormous pressure.

MR. DIXON:—Leave out the pressure—the mere contact of the iron I mean.

MR. PAYNE:—That is probably so. That is often shown by minute cracks that are visible.

MR. HOSTETTER:—It is the consensus of opinion, varying in particulars of course, that there is a difference between what we call chilling action and the strain introduced mechanically in the blowing. The subject is one that may be investigated in great detail. There is here, certainly, a field for investigation.

A MEMBER:—I heard a little incident that may have some bearing on the question of pressing of spectacle lens where a quick, hard action was used instead of a slow, squeezing action. The lens had more tendency to show cracks on the surface due to quick cooling cracks, which the slow squeezing action eliminated.

DISCUSSION[1] ON "A SMALL GLASS TANK"

MR. BELLAMY:—Mr. Chairman and gentlemen, I feel that I should apologize for this paper. After I announced my intention of writing it, I got a letter from Dr. Tillotson asking me to send the paper by return mail, and it was written rather hurriedly. There is one thing you should bear in mind; that we are making glass in much the same manner that a large manufacturer would run his brass melting establishment, and there are many things that come up in our case that do not apply to a large scale production. However, there are some points that will come out in this short paper that may be of interest. In the meeting this morning was discussed the use of blue-water gas for glass melting. We have used blue-water gas for four or five years in melting small quantities of glass, and we have never noticed any serious defects in the glass. However, there is a point that may come up in using it in very large quantities, and that is the formation of iron carbonyl. Blue-water gas passing through the mains comes in contact with the iron and small quantities of iron carbonyl are formed. This product is an unstable gas decomposing, when heated, into carbon monoxide and iron oxide which would of course affect the color of the glass.

[1] Bellamy, *Jour. Amer. Ceram. Soc.*, **5**, 157–60 (1922). Glass Division, St. Louis Meeting, Feb. 28, 1922.

THE CHAIRMAN:—Mr. Bellamy's paper is open for discussion.

MR. WRIGHT:—Mr. Bellamy spoke of using zirkite brick in the crown. He first spoke of silica brick and their tendency to spall. The zirkite brick wasn't used then for its higher heat resistance—higher effectiveness.

MR. BELLAMY:—It was used principally to withstand the severe action on the arch of the flames playing directly on it. Heat resistance also needed for this arch is insulated with a platen of fire brick and about six inches of Sil-O-Cel, so that the top of the crown is not over 100° Centigrade.

MR. HOSTETTER:—In ordinary performance, we find above the middle line it attacks fire clay very rapidly, and it doesn't attack the silica brick. Can you tell something about the attack any the zirkite brick?

MR. BELLAMY:—There is scarcely no action on it.

A MEMBER:—You mean to say you had it insulated?

MR. BELLAMY:—Yes, $4^1/_2$ inches of zircon brick with a course of fire brick laid flat, and then possibly five or six inches of Sil-O-Cel above.

MR. DIXON:—How much glass did the tank hold?

MR. BELLAMY:—About five or six hundred pounds.

MR. DIXON:—How long did you operate it?

MR. BELLAMY:—About a year.

MR. DIXON:—Is that the same tank that is in operation now?

MR. BELLAMY:—Yes.

MR. DIXON:—What kind of glass did you have?

MR. BELLAMY:—High lead glass.

MR. DIXON:—Did you say the capacity of the furnace was five or six hundred pounds?

MR. BELLAMY:—Yes.

MR. DIXON:—Is it daily, intermittent or continual? You put it in the night before? Daily melting?

MR. BELLAMY:—Yes, sir, daily melting.

MR. DIXON:—Have you no record of the temperature?

MR. BELLAMY:—Yes.

MR. DIXON:—What was it?

MR. BELLAMY:—Around 2400°F.

MR. DIXON:—And what did you say the crown was built of?

MR. BELLAMY:—Zirconium silicate. Don't confuse that with zirconium oxide.

MR. DIXON:—And this was insulated?

MR. BELLAMY:—Yes, sir.

MR. WATSON:—I would like to ask if this material is zirconium silicate.

MR. BELLAMY:—Yes, I want to emphasize that. It is not zirconium oxide, but zirconium silicate. It is a brick made by the Carborundum Company.

MR. WATSON:—That brick is of zirconium silicate.

MR. DIXON:—Where is this concern located?

MR. BELLAMY:—Chicago.

MR. DIXON:—May we come up and see it?

MR. BELLAMY:—I am not in a position to say that you can come to see it.

MR. DIXON:—Well, you have made some statements that are very startling and I would like to see it, and would like to make some tests on it.

MR. BELLAMY:—You might send in a request to the Company. I am sure it would be favorably considered.

THE CHAIRMAN:—Is there any particular trade name for these bricks as put out by the Carborundum Company?

MR. BELLAMY:—Zirconium silicate brick.

MR. BROWN:—In four or five or six hundred pound furnaces, you have an entirely different proposition than the most of us have to deal with.

MR. BELLAMY:—The arch is the hottest part of the furnace for the flames come from the burner and impinge on the arch where you get perfect combustion.

MR. BROWN:—What size is the cap?

MR. BELLAMY:—It is about 2 feet across and about 45 inches long.

MR. WRIGHT:—I believe we are all acquainted with the fact that some of the mineral companies are recommending zirkite brick for superrefractories and for crowns of small tanks and especially where high temperatures are obtained. We see their advertisements. I think this is one of the first statements we have had though from actual use and service. It may open up something of very much interest to everyone here.

MR. WATSON:—As I understand the gentleman he is not using zirkite brick but zirconium silicate, which is not the oxide, but the silicate of zirconium.

MR. BELLAMY:—Yes, it is not the oxide.

MR. WRIGHT:—Zirkite brick is one you can buy in three or four different grades. The cheapest grade contains nearly 50% of SiO_2 which is commercially speaking zirconium silicate. They put that out in goods commercially called zirkite brick.

MR. BELLAMY:—The zirconium silicate is handled by the Buckman-Pritchard Company and the brick by the Carborundum Company. They mix a little clay in with the powdered zirconium silicate to produce a cement in which to lay the brick. This arch has produced remarkable results in that there has never been a case of a piece of a brick spalling off. As the zirconium silicate does not harden, the arch has been taken apart brick by brick and set up again which is very desirable as the brick cost a dollar apiece.

MR. DIXON:—Do you know any reason why a large furnace would not do as well as a small crown mixture?

MR. BELLAMY:—No sir.

MR. WRIGHT:—A dollar a brick?

MR. DIXON:—Yes.

MR. WRIGHT:—Zirkite brick would have a specific gravity of 4.5, and silica brick is in the neighborhood of 2. The zirkite crown would be over two times as heavy as the silica brick crown.

MR. BROWN:—Did you insulate this cap?

MR. BELLAMY:—No, I didn't insulate the silica brick.

MR. BROWN:—It fell down?

MR. BELLAMY:—It cracked when the flames impinged upon it.

THE CHAIRMAN:—I would like very much, since this subject has been opened up, to see if we can get one of the Carborundum Co. representatives to give information about this super-refractory.

MR. ONAN:—Mr. Bellamy has read a paper, I understand, on the work he has done with zirconium brick. The material used is not zirconium oxide but natural zirconium silicate. Very little work has been done by anyone other than ourselves on this particular material, and it is still in the laboratory. We are, however, producing some commercial size brick, and we are having some pretty good luck. In the glass tank furnace that Mr. Bellamy built it gave some remarkable service, and we have hope at an early date of trying it out on a larger furnace. Until that time arrives, we can not say just what it will do, or how it will do.

The material we are using is a distinct product. It is a natural combination you can not make up, and its action is not at all like that of zirconium oxide; very little spalling as with silica brick, and it has a very low heat conductivity quite contrary to our other refractories. We are in a position to furnish samples of this material to anybody who wants to look them over and give them a test, but as far as the product being perfected, or putting them on the market, it will be several months before we can do it. If there are any specific facts anybody wants to know, and I can tell them, if they will write to us, we will be very glad to go over the whole proposition.

THE CHAIRMAN:—Have any of you questions you would like to ask the gentleman?

MR. WATSON:—I might state that in the Thompson Laboratory we have made some tests on zirconium oxide and zirconium silicate, and we find there is a vast difference in the two. While the tests are only in their infancy, we have enough data to know there is a considerable difference. One particular difference is the high resistance of the zirconium silicate over the oxide, also the small heating conductivity.

THE CHAIRMAN:—Any further remarks? I certainly would be interested in getting a sample of the refractory. I imagine those present will take advantage of your offer to send samples. I certainly thank you for giving us this information about refractories; it is of great interest to all of us.

ACTIVITIES OF THE SOCIETY

BASEBALL SEASON ENDS WITH BIG SPURT

Manager Bowman Well Pleased with Team's Work

We had a hunch in the Secretary's office that September would see the dust flying on the diamond, and on the fourteenth of the month the forty-second runner slid across the home-plate, bringing the score six runs higher than any other month except the time of the Annual Meeting. Eleven of these, as Corporation Members, made home runs. This is something to tell the world, especially of a month containing ten dog days so doggone hot it was hard to sit at a desk and hold a pen in a perspiring hand long enough to sign on the dratted line.

The batting average follows:

	Personal	Corporation		Personal	Corporation
Chas. F. Binns	2		D. A. Moulton	1	
J. W. Cruikshank	2		Frank G. Roberts	1	
E. W. Dailey	1		Abel Hansen		1
W. W. Wilkins	1		H. F. Staley		1
Ellsworth Ogden		1	Alan G. Wikoff	1	
Chas. Laird	1		Herbert Goodwin	1	
A. M. Kohler	1		J. S. Herzog	1	
Geo. W. Shoemaker		1	J. L. Child	1	
E. P. Poste		1	Charles Brian		1
F. W. Butterworth	1		Gordon Klein		1
Joseph Johnson	1		Werner Malsch	1	
Fred T. Heath	1		H. H. Sortwell	1	
O. O. Bowman, 2nd		1	Donald Hagar	1	
Victor Barth	1		R. R. Danielson	1	
			Office	9	3

Total—31 Personal, 11 Corporation

The net increase for the first eight months of this year is:

	Personal	Corporation	Total
September 14, 1922	1539	199	1738
January 1, 1922	1350	139	1489
	189	60	249

The gross increase in membership by periods since June 1921 is:

	Personal	Corporation	Total
June to September 1921	41	11	52
September to December	18	2	20
December to February 1922	136	21	157
February to May	81	10	91
May	13	13	26
June	13	5	18
July	25	11	36
August	20	5	25
September	31	11	42
	378	89	467
Loss	82	5	87
Net increase	296	84	380

The football season is opening. Last month the goal was set at 200 personal and 100 corporation members.

The referee's whistle has blown. Three months to play, 169 personals, 89 corporations to go. Snap into it, men!

New Members Received from August 11 to September 14

ASSOCIATE

Berry, Sydney G., Gifford & Bull, 141 Broadway, New York City, Patent Attorney.
Blake, Edwin M., Drawer A, Pratt Sta., Brooklyn, N. Y.
Campbell, A. M., P. O. Box 30, Perth, Ont., Canada, Mining Geologist.
Chivacheff, Louie H., Cornwall-on-Hudson, New York, Instructor Drawing and Manual Training.
Christie, Charles H., 602 N. McKean St., Butler Pa., Standard Plate Glass Company.
Coon, Darius A., Storrington Feldspar Co., Elgin, Ont., Canada, President.
Dorsey, Frank M., Nela Park, Cleveland, Ohio, Consulting Engineer, G. E. Co.
Doughty, I. N., 223 Kentucky Ave., Danville, Ill., Gen. Supt., Western Brick Company.
Elliott, Harry C., Cascade China Co., Portland, Ore., Pres. and Treas.
Gandefte, Charles A., 661 New Willow St., Trenton, N. J., Trenton Potteries Co. Laboratory.
Gifford, Maurice S., 142 Osborne Ave., Libertyville, Ill., Chief Chemist, Chicago Hardware Foundry Co., North Chicago, Ill.
Green, John R., 319 S. Maryland, Mason City, Ia., Ceramic Engineer, North Iowa Brick & Tile Co.
Greer, W. Russell, 1938 Linden Ave., Baltimore, Md., Porcelain Enamel & Mfg. Co.
Ingler, William J., Holophane Glass Co., Inc., Newark, Ohio, Asst. Supt.
Jarmuth, Otto C., 9120 Commercial Ave., Chicago, Illinois, Art Director.
King, Robert Maynard, Box 103, Sta. A., Columbus, O., Student, O. S. U.
Kleymeyer, Henry C., Standard Brick Mfg. Co., Evansville, Ind., Gen. Mgr.
Lambert, Frank B., Illinois Brick Co., Chicago, Ill., Gen. Supt.
Landers, William H., 4 West 43d St., New York City, Consulting Engineer.
Marr, William H., c/o Canadian Libbey-Owens Sheet Glass Co., Hamilton, Ont., Canada, Supt.
Moller, Knud J. Chr., 4956 McPherson Ave., St. Louis, Mo., Chem. Engineer.
Owen, Frank E., The Findlay Electric Porcelain Co., Findlay, O., Sec. and Mgr.
Schroeder, Fred W., U. S. Bureau of Mines, Seattle, Wash.
Shearer, Walter L., 3044 Dent Place, N. W., Washington, D. C., U. S. Bureau of Standards.
Smith, Stanton G., Box 94, Auburn, Me., Maine Feldspar Co., Mgr.
Smith, Walter C., 654 St. Nicholas Ave., New York City, Sales Mgr., N. J. Pulverizing Company.
Taylor, Mark A., Terminal Bldg., Ft. Dodge, Iowa, Ceramic Eng., Vincent Clay Products Company.
Thompson, J. S., The Excelsior Dental Mfg. Co., Grace Road, Aintree, Liverpool, England, Managing Director.
Walker, Thomas C., Mosaic Tile Co., Plant No. 2, Matawan, N. J., Ceramic Engineer.
Winton, Lewis B., Great Barrington, Mass., Gen. Mgr., Stanley Insulating Co.
Zimmer, Daniel B., 1381 Sedgwick Ave., New York City, Treasurer, Vitreous Enameling & Stamping Co., Inc.

CORPORATION

Auld Co., D. L., 5th St. and 5th Ave., Columbus, Ohio.
American Stove Company, 2001 S. Kingshighway, St. Louis, Mo.

The Clay Products Co., Brazil, Indiana.
Fords Porcelain Works, Perth Amboy, N. J.
Metal & Thermit Corp., 120 Broadway, New York City.
N. C. Geological & Economic Survey, Chapel Hill, N. C.
Paper Makers Importing Co., Inc., 640 N. 13th St., Easton, Pa.
The Patterson Foundry & Machine Co., East Liverpool, Ohio.
Springfield Paving Brick Co., Box 403, Springfield, Ill.
The Trenton Potteries Co., Trenton, New Jersey.
The Vitreous Enameling Company, 71st and Grant Ave., Cleveland, Ohio.

Who's Where in the American Ceramic Society?

T. S. Curtis, president and general manager of the Vitrefrax Company, has notified the office of a change of address from North Rugby Avenue to 534 S. Seville Street, Huntington Park, Los Angeles, Cal.

Cedric L. Rennieburgh has recently taken a position with the A. C. Spark Plug Company, at Flint, Mich. Mr. Rennieburgh was formerly with the American Encaustic Tiling Company, Zanesville, Ohio.

W. W. Ittner has moved from Pershing Avenue to 2107 Park Avenue, St. Louis, Mo. His connection with the General Clay Products Corporation as treasurer continues.

George W. Hasslacher, of the Roessler & Hasslacher Chemical Company, sailed for Germany on September 16. He will be located for some time at the Deutsche Gold and Silber Scheideanstalt, Frankfurt, a./M.

H. M. Reed has moved from Pittsburgh to 106 Dixon Avenue, Ben Avon, Pa.

Ira E. Sproat took charge, on September first, of the Ceramic department of the R. T. Vanderbilt Company, New York City.

Waller Crow, formerly secretary-treasurer of the Schaffer Engineering and Equipment Company, Pittsburgh, Pa., is now president of his own company, Waller Crow, Inc., Chicago, Ill.

J. Alfred Dennis, of the Golding Sons Company, has been made superintendent of the Golding-Keene Company, Keene, N. H.

F. P. Hall, of the Bureau of Standards, Washington, has changed his residence from Crittenden Street to 630 Webster Avenue.

J. Ellis Harvey, general manager of the Centre Brick and Clay Company, is now located at Ridgway, Pa.

Arthur L. Koch gives as his new address, 1748 Wellesley Avenue, St. Paul, Minn.

J. B. Owens, of the Empire Floor and Wall Tile Company, has moved from Zanesville, Ohio, to 137 West 25th St., New York City.

R. R. Shively has just been appointed chief technologist for B. F. Drakenfeld & Company, New York City, where he will be technical advisor to the officers of the company. For eleven years Dr. Shively has served as industrial fellow at Mellon Institute, where he has specialized on glass and glass-making materials.

M. G. Babcock, formerly of the Pittsburgh office of the Laclede-Christy Clay Products Company, has been transferred to their Rochester plant, to handle the sales of all glasshouse refractories manufactured there. Mr. Babcock's territory will comprise all pot glass manufacturers in the United States and Canada.

T. M. McVey, recently of the Lacon Clay and Coal Company, Lacon, Illinois, has been appointed instructor in the Ceramics department at the University of Illinois.

T. W. Garve, recently located at Watsontown, Pa., has returned to Columbus, and may be found at 47 North 20th Street.

Herman Coors, who severed his connection with the Coors Porcelain Company some time ago, is now established at 3768 Dalton Avenue, Los Angeles, Cal.

A. Malinovszky, formerly with the U. S. Smelting Furnace Company, Belleville, Illinois, has gone to Long Beach, California.

H. P. Reinecker, formerly with the Bureau of Standards, Washington, has accepted a position with the Pacific Enameling and Manufacturing Company, Oakland, Cal.

Robert F. Sherwood, has left the Muncie Clay Products Co., Muncie, Ind., and has taken a position with Pass & Seymour, Inc., at Syracuse, N. Y.

Chester Treischel has been transferred by the General Electric Company to the Pittsfield works, Pittsfield, Mass.

Carl G. Zwerner, who has been with the Northern Clay Company, Auburn, Wash., for some time, has returned to Columbus, where his address is 58 West Tenth Avenue.

Addresses Unknown

Any information as to the whereabouts of the following members of the Society will be gratefully received by the Secretary's office. Mail has been returned from the addresses given.

Baker, G. V., Penn Feldspar Co., Philadelphia, Pa.
Bickel, Earl A., Postville Clay Products Co., Postville, Iowa.
Bramlett, Mrs. J. T., Enid, Miss.
Brett, R. C., Southern Clay Mfg. Co., North Birmingham, Ala.
Buckner, O. S., 44 Wellington St., Worcester, Mass.

Callaghan, J. P., c/o Teaque Hotel, Montgomery, Ala.
Curran, Hugh, Bakersfield Sandstone Brick Co., Bakersfield, Cal.

Dolley, Charles S., Keramoid Mfg. Co., Fort Madison, Iowa.

Fiske, J. Parker B., Arena Bldg., New York City.

Greenwood, John L., Lehigh Sewer Pipe and Tile Co., Lehigh, Iowa.

Hall, Herman A., McLain Fire Brick Co., Vanport, Pa.
Henshaw, S. B., Libbey-Owens Sheet Glass Co., Charleston, W. Va.

Knote, J. M., Mines Dept., L. S. Corp., Sault St. Marie, Ontario.

Meissner, Max, Sprague Canning Machine Co., Hoopeston, Ill.
Miller, J. J., Mellon Institute, Pittsburgh, Pa.
Mitchell, Leon W., Rock Island Stove Co., Rock Island, Ill.
Mulholland, V., 41 Arch St., Hartford, Conn.

Nagle, J. A., 196 Oak St., Columbus, Ohio.

Pendrup, W., Coonley Mfg. Co., Cicero, Ill.
Pire, Mrs. Ward L., 1745 East 116th Place, Cleveland, Ohio.
Pulsifier, H. M., Geo. H. Holb & Co., Chicago, Ill.

Ragland, N. A., Alberhill Clay and Coal Co., Los Angeles, Cal.
Reid, W. H., 10 Stanley Place, Yonkers, N. Y.

Stewart, John G., 530 Union Trust Bldg., Cincinnati, Ohio.

Tefft, T. D., Hamilton, Ont.
Trace, A. R., National Fire Proofing Co., Hobart, Ind.

Vodick, William J., 1733 Lake Ave., Wilmette, Ill.

Yamamoto, Tamesburo, Yamatame Glass Mfg. Co., Osaka, Japan.

Exhibit of Ceramic Wares

TWENTY-FIFTH ANNIVERSARY CONVENTION, FEB. 12–17, 1923

The Art Division, under the chairmanship of Frederic H. Rhead, is planning an exhibit for this convention. Plans have not as yet been fully formulated but the occasion suggests the scope and character of the exhibit desired.

The several Divisions will be asked to coöperate in making an exhibit illustrative of the twenty-five years of development in their respective industrial groups. Ample space conveniently located has been secured in the hotel.

The American Ceramic Society at the Chemical Show

BY ALAN G. WIKOFF

The American Ceramic Society was well represented at the Eighth National Chemical Exposition the week of September 11. At the opening meeting President F. H. Riddle[1] gave an address; Friday, September 15, was "Ceramic Day" when a program of fifteen papers was presented before an audience of 150. Two booths were maintained throughout the week as headquarters for the members of the Society.

Mr. Riddle's talk on "The American Ceramic Industry" was an excellent presentation of a subject which is gaining daily in importance to the world. His definition of the term "ceramic" was careful and his classification of the ceramic branches concise and of vital interest. The paper discussed further the following points:

1. Standards for Purchase
2. Industries Described
   - (*a*) Hollow-ware
   - (*b*) Architectural Terra Cotta and Tile
   - (*c*) Brick
   - (*d*) Glass
   - (*e*) Enameled Steel and Iron
   - (*f*) Abrasives
   - (*g*) Refractories, Silica, Aluminum, Magnesia, Etc.
3. Progress of Ceramic Work during the War
   - (*a*) Development of Better Refractories
   - (*b*) Enameled Iron
   - (*c*) Chemical Stoneware
   - (*d*) Graphite Crucible
4. Relation between Ceramic Interests
5. The American Ceramic Society

Ceramic Day formed a fitting climax to the technical programs held in conjunction with the Eighth National Exposition of the Chemical Industries. At the afternoon session papers of a high order of merit were presented on a variety of ceramic subjects. The meeting was exceptionally well attended and those in the audience who were not members of the American Ceramic Society took away with them a clearer conception of the importance and magnitude of the ceramic industry. They realized, perhaps for the first time, the many points at which this industry touched their daily lives. For the members there was much of real technical value, and the assimilation of important information was facilitated by carefully prepared lantern slides and ingenious models in several instances.

[1] This paper will be published in full in this *Journal*, January, 1923.

The following papers were given:

W. H. Gaylord, Jr. (Quigley Furnace Specialties Co.), "High Temperature Cements."

E. S. Hirschberg (Ding's Magnetic Separator Co.), "Application of Magnetic Separator in Ceramic Industries."

G. D. Dickey (Industrial Filtration Corporation), "Preparation of Clays and Minerals for Ceramic Purposes."

Eric Turner (Trenton Flint and Spar Co.), "Apparatus for Quickly Determining Fineness of Grind."

W. H. Landers, George M. Darby, O. O. Bowman, 2nd, August Staudt, C. R. Moore, C. M. Franzheim, "Feldspar Colloquium."

H. C. Arnold, "Manufacture of Gray Enameled Ware."

A. E. Williams, "Whiting for Ceramic Uses."

C. B. Chapman (Chapman Engineering Co.), "Gas Producers for Glass Works."

Paul E. Cox, "Witchery of Glazes."

Conrad Dressler, "Architectural Faience and Its Artistic Possibilities."

Frederic H. Rhead, "Organization of a Decorative Ceramic Research Department: Financial and Manufacturing Considerations."

Earle N. McGee (Semet-Solvay Co.), "Testing Refractories."

Charles E. Kraus (Johns-Manville Inc.), "High Temperature Cements."

F. P. Nickerson (W. S. Tyler Co.), "Sieve Testing of Ceramic Materials."

H. F. Kleinfeldt (Abbé Engineering Co.), "The Grinding of Ceramic Materials."

In the evening, the Society contributed two important papers to the symposium on Standardization arranged by the New York Section of the American Chemical Society.

1. Ross C. Purdy discussed some of the problems encountered in attempting to standardize fire clays and refractories.

2. Emerson P. Poste presented a series of lantern slides illustrating what is being accomplished toward the standardization of enameled wares for chemical purposes.

NOTES AND NEWS

Calendar of Conventions

The Silver Jubilee of the AMERICAN CERAMIC SOCIETY will be celebrated at the next Annual Meeting which is noted on this list. Watch for the announcements as they appear in other portions of this *Journal*.

American Mining Congress—Cleveland, Ohio, October 9–17, 1922.

Society of Industrial Engineers—New York City, October 18, 1922.

National Association of Commercial Organization Secretaries—Chicago, Ill., October 23–25, 1922.

National Society for Vocational Education—Detroit, Mich., November 30–December 2, 1922.

Dental Manufacturers Club—St. Louis, Mo., November 20, 1922.

Dental Exhibit of the Dental Manufacturers Club—St. Louis, Mo., November 21–24, 1922.

National Exposition of Power and Mechanical Engineering—New York City, December 7–13, 1922.

Mining and Metallurgical Society of America—New York City, December 7–13, 1922.

American Malleable Castings Association—Cleveland, Ohio, January 10, 1923.

National Jewelers Board of Trade—New York City, January 18, 1923.

Canadian National Clay Products Association and Western Ontario Clay Workers Association—Hamilton, Ont., January 24–26, 1923.
American Concrete Institute—Detroit, Mich., February, 1923.
National Association Builders Board of Control—Des Moines, Iowa, February, 1923.
AMERICAN CERAMIC SOCIETY—Pittsburgh, Penna., February 12–17, 1923.
National Gas Association of America—Louisville, Ky., Spring, 1923.
American Institute of Mining and Metallurgical Engineers—New York City, February 19–22, 1923.
National Association of Stove Manufacturers—Richmond, Va., May 9–10, 1923.
American Association of Museums—Charleston, S. C., May, 1923.

I STEEL FOUNDRIES COOPERATE IN JOINT RESEARCH
II COORDINATING FOUNDRY CONTROL
III SCIENTIFIC INVESTIGATIONS LEAD TO BETTER PRODUCT
IV IDEAS FREELY INTERCHANGED

These headlines appeared in a recent issue of *The Iron Trade Review*.[1] The stories told were of the coöperative research and plant control in which five steel foundries are engaged under the direction of Major R. A. Bull. Electric Steel Co., Chicago; Fort Pitt Steel Coasting Co., McKeesport, Pa.; Michigan Steel Casting Co., Detroit; Sivger Steel Casting Co., Milwaukee are thus coöperating.

With improved quality as the goal and diligent teamwork as the means to that end group research has proved its worth to associated manufacturers producing a common product. No more trying conditions could be imagined for testing the worth of coöperative research than the depression which has marked almost the entire period of the association of five progressive steel casting manufacturers in the Electric Steel Founders' Research Group. While some large manufacturing interests possessed of practically unlimited means have cut their research appropriations to the bone, have lightened their overhead by reducing and even in certain cases dismissing entire research staffs, abandoning projects and sacrificing results of years of endeavor, this small body of steel casting producers has held steadily to its purpose, sustained by its faith in the ultimate outcome. Consequently, its members, emerge into the period of keen competition at hand well equipped in shop methods, quality of product, and organization morale.

This statement may seem exaggerated to those who are not familiar with the breadth and character of the work being done by this group. It will be difficult to understand without a knowledge of the accomplishments of the plan how, for example, the organization morale of the individual members could be appreciably benefitted. However, this assertion is fully supported by a familiarity with the facts which have been established. The idea of group research and coöperative effort between five manufacturers making a similar class of steel castings had its inception early in 1920, when in response to a call by C. R. Messinger, of the Sivyer Steel Casting Co., a meeting was held in Pittsburgh, Feb. 25, 1920. Here a plan was outlined whereby technical problems could be solved by the combined efforts of the foundries associated.

Obviously, the basic requirements of an association of this character were implicit confidence between the members and the unselfish interchange of data. How well the idea has been carried out will be evident from the results attained. Improvement in quality of product, the underlying purpose in forming the group, required the supervising control of a recognized expert in steel foundry practice. The company secured the exclusive services of Maj. R. A. Bull, who had long been a dominant figure in the industry through his association with the Duquesne Steel Foundry Co., as Vice President

[1] D. M. Avey, page 1472. *The Iron Trade Review*, May 25, 1922.

and General Manager, and previously with the Chicago Steel Foundry Co., the Commonwealth Steel Co., and the American Steel Foundries. Major Bull's activity in the American Foundrymen's Association, of which he was president in 1915 and 1916, had further fitted him for the task of organizing and correlating the staffs of the various members of the group. The wisdom of his selection is attested by the ready response and hearty coöperation observed among the superintendents, foremen and workmen in their attitude toward the research director, as Major Bull is termed.

Recognizing, from the first, the dual nature of the problems to be encountered, a working organization within the group was formed. This had two controlling committees, the general committee, having the decision on questions of policy, finance, and cost; and the technical committee, dealing with operating problems. At present these committees are made up as follows:

GENERAL COMMITTEE

Chairman, C. R. Messinger, vice president and general manager, Sivyer Steel Casting Co.
R. F. Flinterman, president, Michigan Steel Casting Co.
C. S. Koch, president, Fort Pitt Steel Casting Co.
John M. Olmsted, vice president and general manager, Electric Steel Co.
T. S. Quinn, treasurer, Lebanon Steel Foundry.

TECHNICAL COMMITTEE

Chairman, William J. Nugent, vice president and works manager, Electric Steel Co.
R. J. Doty, vice president and works manager, Sivyer Steel Casting Co.
C. S. Koch, president, Fort Pitt Steel Casting Co.
T. S. Quinn, treasurer, Lebanon Steel Foundry.

The question of selling prices for castings was banned from the start. Costs were considered only as an abstract problem; but the scientific study of costs to bring about more economical manufacture while maintaining and, when possible, improving quality, has been one of the most beneficial results of the association.

The group's scheme of operation may be briefly indicated under five main heads. Broadly speaking, the results are obtained through the following means: Frequent meetings of group representatives; investigations authorized at these conferences and conducted at suitable plants; general inspections of each plant by the research director; transmission regularly of reports to and from the director; and the use of the director's office as a clearing house and distributing center for all technical information of value to the members.

The meetings are held frequently and usually last for three days. In most cases they are held where one of the member plants is located and each such plant is visited at a time when the greatest benefit may result from critical and thorough examination by all representatives of the accomplishments of the investigation at that time justifying joint consideration on the ground. These meetings are attended by the principal operating executives themselves and, as occasion may warrant, by some of their chief subordinates in close touch with the problems under consideration. Consequently, questions of operating expediency can be decided immediately through the authority vested by each company in its delegated representatives. The great advantage of this will be obvious.

A typical meeting is a scientific convention in miniature. The members to whom the group has delegated specific researches are required to present detailed written reports of these investigations showing the progress to date. These reports are mailed by the authors to each of the plants and to the director sufficiently in advance of each meeting to permit prior study by all conferees. The critical consideration given these progress reports is exhaustive, and leads to agreement as to the further steps for each investigation. These occasionally require the participation of more than one plant in one research to test the application of a theory under different local conditions. Supplementing the reports by the members, the research director analyzes the status of the

work and presents for consideration such additional problems for investigation as he feels profitably may be attacked next. Before adjournment, definite decision is reached on all matters the solution of which is possible, thus permitting the group to function with the utmost dispatch.

Research in each case is assigned to the plant believed to have the most suitable personnel and equipment for the purpose after recommendation along these lines by the director. Such an investigation is conducted at joint expense. It requires the immediate supervision of a properly qualified man who in many cases for a time may be the operating head of the member plant. In every instance this individual is held responsible. The serious manner in which the work is carried on will be apparent from this. The man on the ground making an investigation is given all possible assistance by the director who periodically visits the plant for personal participation in the researches under way. An exhaustive record is kept of every detail of each research. Therefore, the complete series of progress reports on any investigation is convincing.

FEDERAL SPECIFICATIONS BOARD

U. S. Bureau of Standards

When General Dawes started to put the budget system in operation in the various Departments of the Federal Government, it soon became apparent that it would be necessary, in order to inaugurate an effective purchasing system, to first provide specifications for a vast number of articles. Considering the fact that Government specifications have long been a bugbear to those who have had experience with Government Departments as customers, it might seem that there were too many Government specifications already. Since in many instances, different Departments had different specifications for the same thing, this may have been the case; the need was not for more specifications but for *one* adequate specification for each product or material. Standards of quality had to be established and uniform specifications prepared.

In order that this stupendous undertaking should be carried out systematically, a new agency, to be known as the Federal Specifications Board, was created by executive order. It was entirely logical that Dr. Stratton, Director, since its founding twenty-one years ago, of the Bureau of Standards, should be made chairman of this new board which has to pass on all specifications prepared for the use of the Government Departments. It is a matter for mutual congratulation, considering the standardization work that is being undertaken by the AMERICAN CERAMIC SOCIETY, that the Director of an institution which is already working in close coöperation with the Society should be at the head of the organization which is to unify the government standards.

Germany Tending to Impress its Industrial Standards on All Import Countries

American Engineer, Back from Germany, Reports Industries There Gaining Big Advantages through Standardization

"The day may not be far distant when American manufacturers will receive inquiries from oversea countries to furnish goods according to the German national standards, and it behooves us to plan in time to meet such conditions."

This statement is contained in a communication to the American Engineering Standards Committee from Oscar R. Wikander, an American engineer, who has just returned from Germany, where he represented the A. E. S. C. in conferences concerning the international standardization of ball bearings.

Describing the great strides in standardization that have been made by German industries during the last few years and the important foreign trade advantages accruing to German industries because of their intense standardization activities, Mr. Wikander said:

"There is no doubt in my mind that one of the main reasons why forward-looking Germans force their standardization work is because they want to introduce German standards in the great importing countries, and possibly in the whole world. Holland, Switzerland, Austria, Sweden, and many other European countries follow the German lead very closely. The great German deliveries in kind to France will no doubt be made as far as feasible according to German standards, thereby introducing them in that country.

"It was only a few years ago that the 'Normenausschuss der Deutschen Industrie,' an organization corresponding to our American Engineering Standards Committee, was formed but the amount of work which it has already accomplished is stupendous. The 'Normenausschuss' has already issued several hundred sheets of approved standards, and about twice as many are already published as proposed standards. This enormous output of the German organization has led many to believe that it was merely a factory, producing 'paper standards,' and that its work was not to be taken very seriously. A personal investigation convinced me that this is not the case, and I found that the great output of standards was merely due to the enormous efforts put forth and to the enthusiasm of the great majority of the interested parties.

"This enthusiasm is due to a more or less general recognition, created under the pressure of war conditions, of the great economic value of standardization, and to the very generally accepted opinion that a standardized industry would be one of the strongest weapons in Germany's struggle for economic rehabilitation and financial reconstruction.

"To give a concrete illustration of this point, I may mention that at the time of my visit, a syndicate of nineteen German manufacturers and one Swedish manufacturer were executing an order for seven hundred locomotives for Russia, all of the same design, and every part in every one of them was being made interchangeable with the corresponding part in all the others, all parts having been manufactured to the same fits and tolerances. This feature will have the great advantage of permitting the Russian railroads to use any disabled locomotive as a store of spare parts for all the others. In one case a locomotive was assembled from parts machined in twenty different shops, with no more difficulty than a locomotive which was built complete in one shop. In case of future orders, the Russians will no doubt specify that all new locomotives of this class be built not only of the same design as above, but so that every part is interchangeable with the above.

"It is easy to realize what great advantages German manufacturers of locomotives will have over those of other nations when competing on the basis of such specifications, and this example illustrates the economic advantage which can be gained by German industry in introducing its standards in all countries importing mechanical equipment.

"Another error in our conception of German standardization is the belief that the 'Normenausschuss' is autocratic in its methods and is not in as close contact with the industries as our own standardizing bodies. I found, on the contrary, that absolutely the same methods are used there as here to arrive at national standards. The staff of the 'Normenausschuss' is merely coördinating and directing the work of the various committees, and the actual work in establishing standards is left to such experts as are recognized leaders in the various industries.

"The 'Normenausschuss' is a big organization built up along the same lines as the American Engineering Standards Committee. Its personnel consists of the same high

grade type of men as selected in this country for that kind of work,—only there are more of them and their work is greatly facilitated on account of the eager response from the German industry, whose leaders look to standardization as one of their greatest hopes for salvation.

"Many of the big German manufacturers have standards departments of their own, with a number of engineers and draftsmen working permanently on national standards. I found the staff of the 'Normenausschuss' greatly interested in American standardization and very anxious to collaborate with us in establishing international standards.

"It was proposed that they should send the American Engineering Standards Committee all the drafts of any importance submitted to their own committees for consideration, so as to make it possible for them to obtain American comments on important propositions, which might be of value in making final decisions. It was also suggested that the American Engineering Standards Committee keep the 'Normenausschuss' posted on its more important work. It would, of course, be highly desirable to establish international standards and great efforts are being made to obtain them in certain lines, such as ball bearings.

"The days may not be far distant when our manufacturers will receive inquiries from oversea countries to furnish goods according to the German national standards or specifications, as referred to above in connection with the Russian locomotives, and it behooves us to plan in time to meet such conditions, England seems to have realized fully the importance of recognition of her standards, and is trying to force the adoption of them in her colonies and dominions.

"On account of its very efficient organizations, the German Standards Committee has come to play a more important rôle in the industrial life of the nation than originally expected and manufacturers write to the 'Normanausschuss' for advice on questions of the most intricate nature.

"In conclusion I wish to express the hope that the example of the German engineers and manufacturers may spur us to make equally large contributions in work and money to the cause of standardization, and that our leading engineers may try to realize the enormous economic importance of both national and international standards."

Storage and Transportation of Portland Cement

(With a Bibliography)

By W. M. Myers (Assistant mineral technologist, U. S. Bureau of Mines).

The U. S. Bureau of Mines conducted an investigation to determine the cause of the deterioration of Portland cement during storage and transportation, and to discover a means of preventing it. All available printed sources of information on this subject have been examined and a bibliography has been compiled. The subject has also been discussed with the leaders in the cement industry; the present report is the result of their coöperation, and is based principally on information thus obtained.

Deterioration of Portland cement during storage over any considerable period of time has long been noted; closely related to it is deterioration of cement during transportation, which involves not only the time factor of storage but also exposure to varied climatic conditions. Deterioration in both cases is due to hydration of the cement by absorption of moisture from a humid atmosphere, or by exposure to actual rain-fall. After hydration cement possesses no cohesive power; the degree of deterioration is directly proportional to the degree of hydration.

The amount of deterioration of Portland cement during storage has been accurately determined in an investigation by the Structural Materials Research Laboratory, in

coöperation with the Portland Cement Association. Cement stored in a shed in cloth sacks retained 80 per cent of its original strength after three months' storage; 71 per cent after six months; 61 per cent after one year; and 40 per cent after two years.

Storage and Transportation of Portland Cement in Bulk.—Deterioration of cement stored in bulk is less than in bags, owing to the smaller area exposed. Hydration takes place only at the exposed surface, and the bulk of the cement is unaffected. Cement transported in bulk must be shipped in a tight, closed car, and must be protected from moisture during loading, shipping, and unloading, preferably it should be used immediately after unloading at the point of destination. This practice is now followed by several manufacturers and where conditions are suitable it is becoming more common as its advantages are seen. Shipping in bulk effects a saving by eliminating the use of bags—which is an important item in the cost of cement and it should also permit a saving in freight rates.

Storage and Transportation as Unground Clinker.—Clinker, the fused product of the cement kiln before it is ground to form the finished Portland cement, is exceptionally well adapted for transportation or storage over long periods of time under adverse conditions. It is extremely inert and has no tendency to absorb moisture. Experiments show that clinker may be stored under water, or subjected to alternate dry and wet storage, without lowering the quality of the finished cement.

This cement has two distinct advantages: The quality of the cement produced from stored clinker is higher, and the grinding cost of the clinker is decreased because of mechanical disintegration.

The improvement in the quality of cement made from stored clinker is due to the hydration of any free lime (CaO) that may be present. Free lime is injurious to the finished cement, as it produces unsoundness. It is not present in a perfectly burned clinker, but it is present occasionally as a result of imperfect mixing of raw materials and of careless manipulation. Cement manufacturers, therefore, generally store clinker for several weeks or months before grinding. Clinker that produced unsound cement in one instance was found to yield a satisfactory product after being treated with steam to hydrate the free lime.

Though Portland cement in the form of clinker is most carelessly handled and stored without regard to humidity or climatic conditions, yet improvement rather than deterioration of quality is manifest in the ground product.

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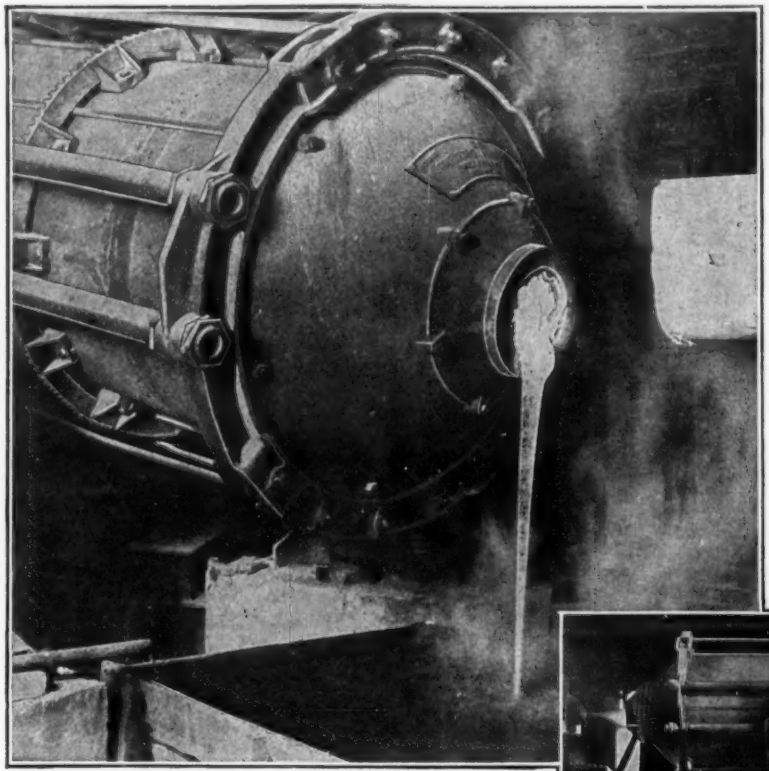
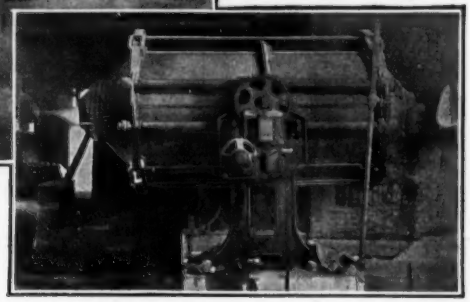
1921. December p. 95–99
1922. January p. 11–14
1922. February p. 30–34

Management Week

The American Society of Mechanical Engineers has designated the period from October 16 to 21 as "Management Week" in order to stimulate interest in the solution of problems of management in industry. During this time meetings will be held by the Local Sections in coöperation with other engineering societies, including the Taylor Society and the Society of Industrial Engineers.





These illustrations made from photographs taken in the plant of Ingram-Richardson Mfg. Co., Beaver Falls, Pa.

12-21

"Our U. S. Enamel Furnaces Increase Output 25% per day at a Saving of 50% in Fuel Cost."

Ingram-Richardson Mfg. Company claim those remarkable results for their U. S. Enamel Furnaces. With four U. S. Furnaces operating at their plants at Frankfort, Indiana, and Beaver Falls, Pa., they are saving thousands of dollars yearly in fuel and labor.

Their white and colored enamels are smelted in quick time, with low loss. The work is easy and sure. The Furnace is under perfect scientific control. The melting process is visible. The Furnace rotates while melting and tilts when pouring. Linings last longer and cost less.

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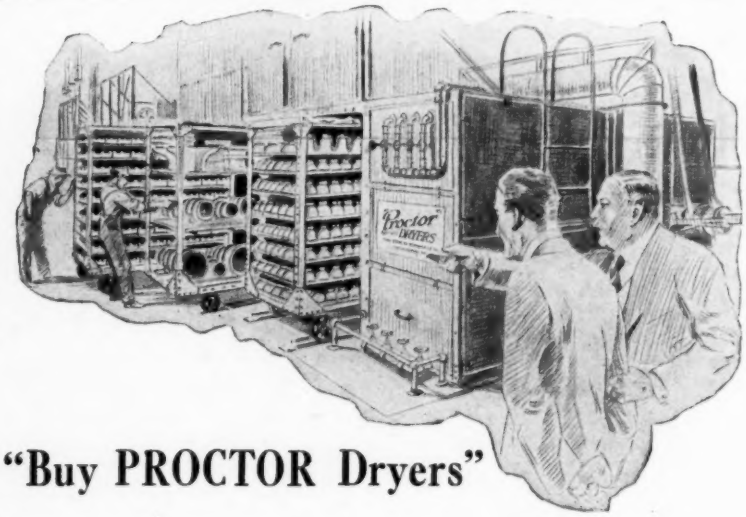

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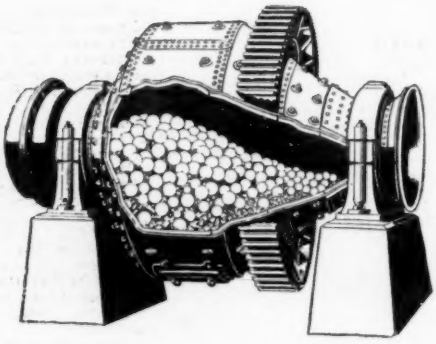

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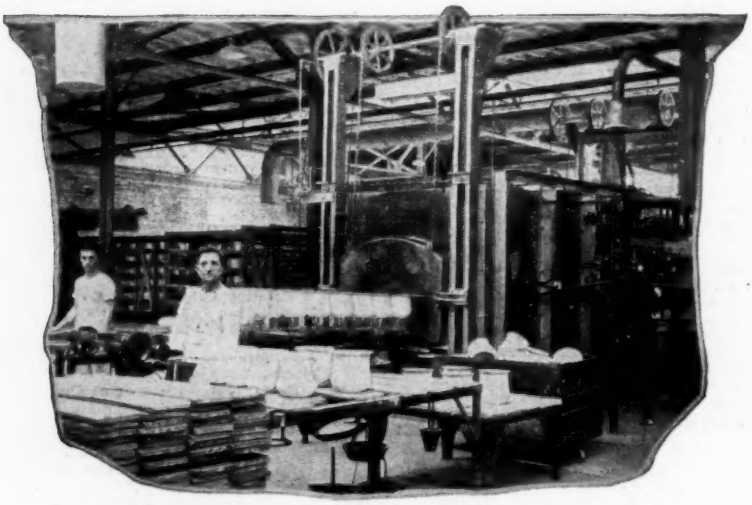

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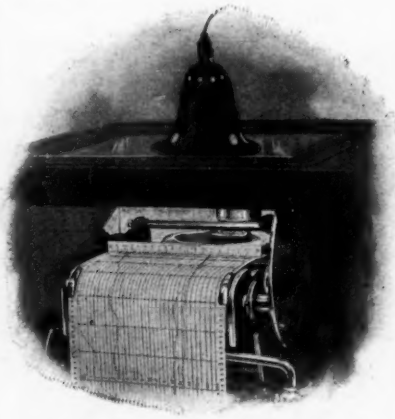

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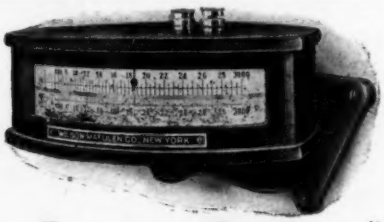

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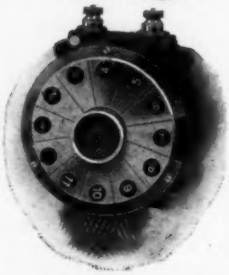

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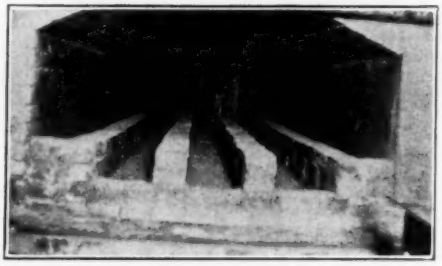

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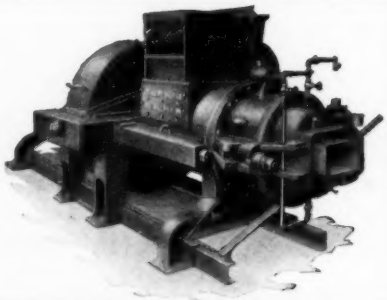

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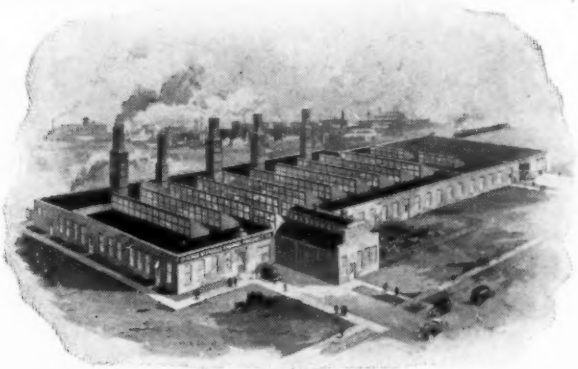

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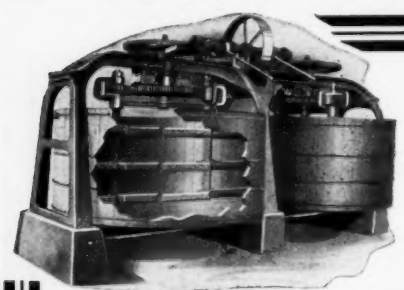

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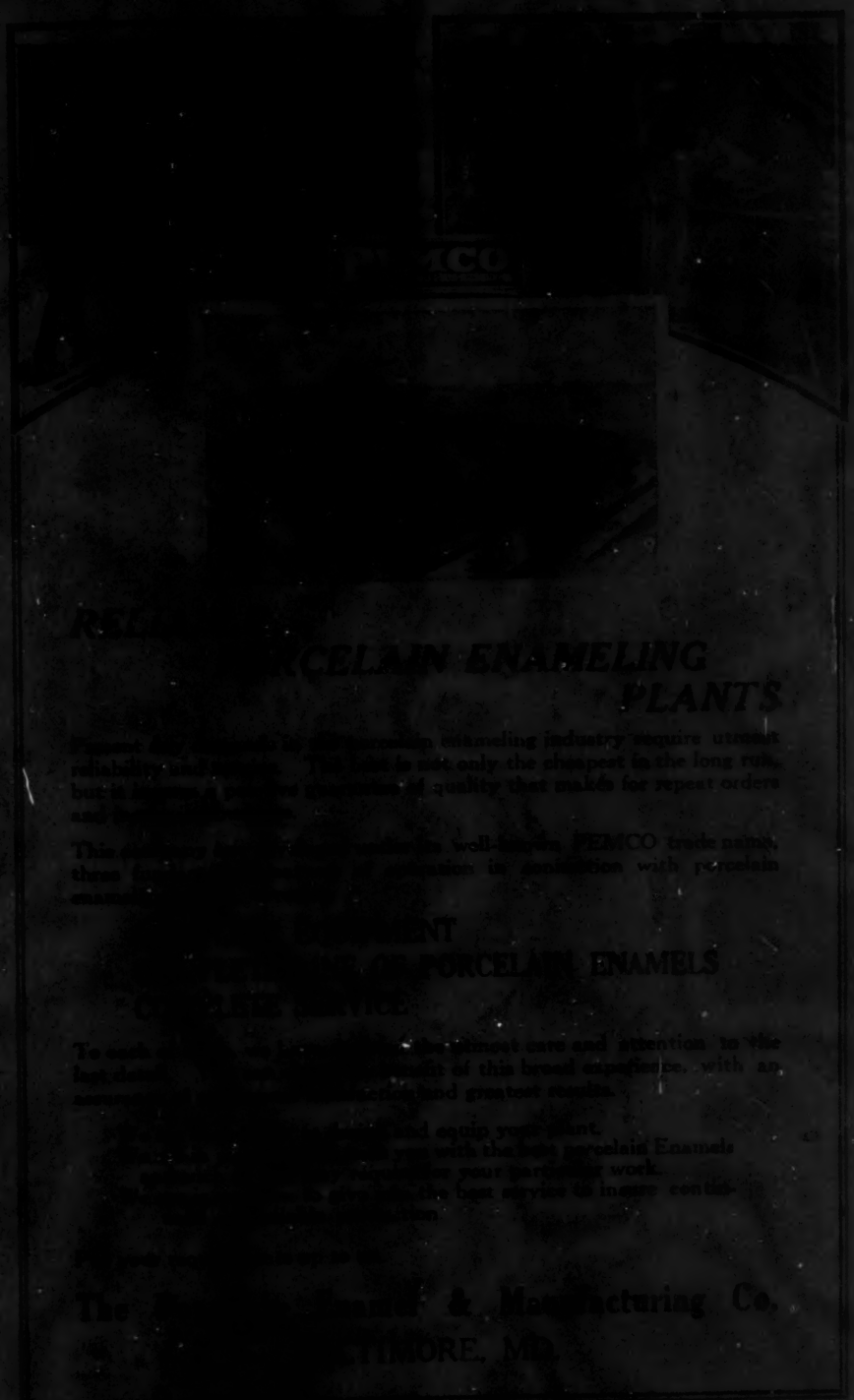

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